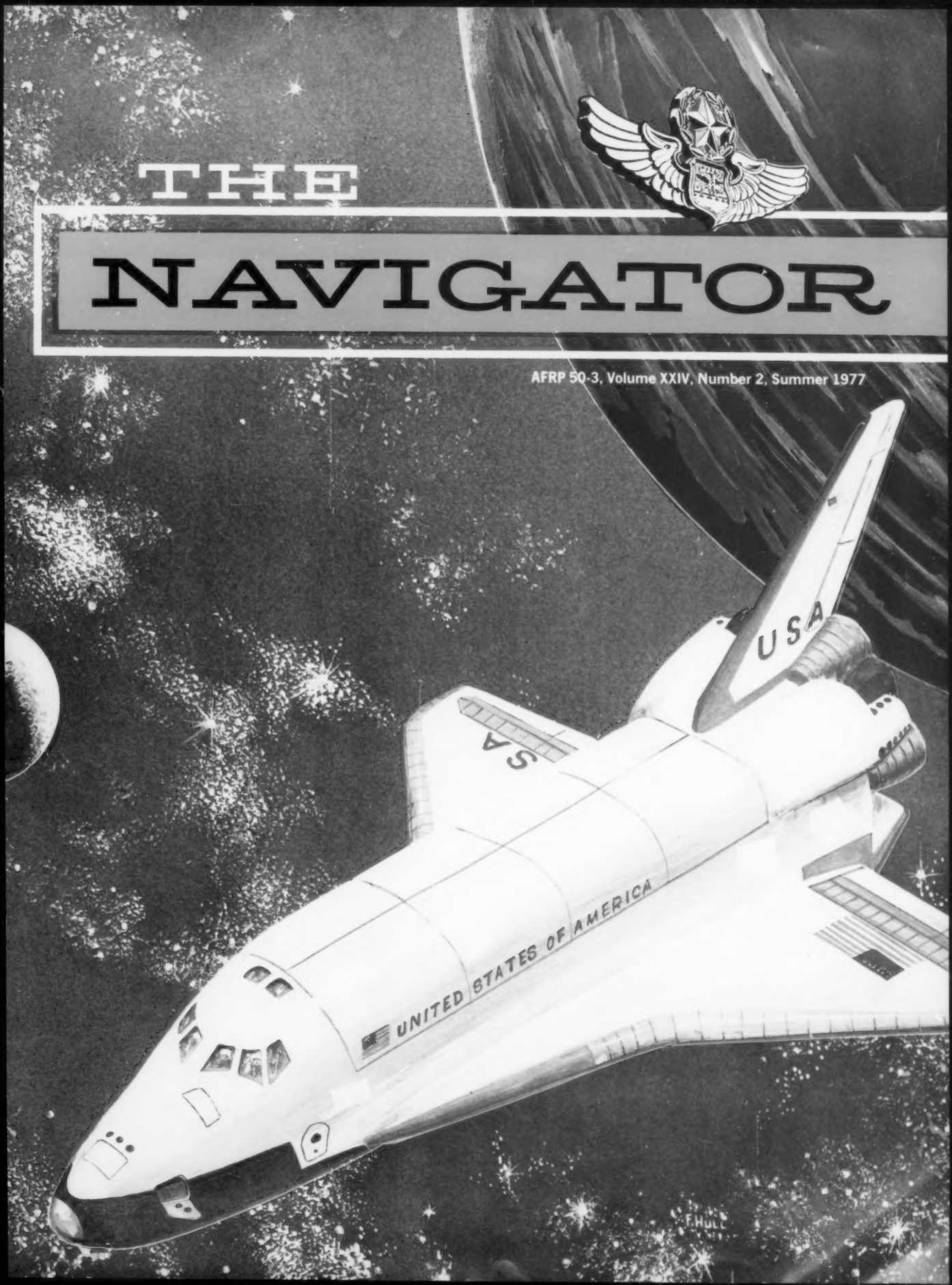
THE
NAVIGATOR
AFRP 50-3, Volume XXIV, Number 2, Summer 1977
USA
UNITED STATES OF AMERICA
F. HULL

NAV OF NOTE

Colonel James G. Jones is the Deputy Commander for Operations (DO), Wild Weasel, of the 35th Tactical Fighter Wing, George Air Force Base, California. In this capacity, he is responsible for the development of Wild Weasel employment concepts, operation of the Weasel training program, and the combat readiness of Tactical Air Command's Wild Weasel force.

Colonel Jones was born in Hamilton, Ohio, on 1 September 1934, and attended school in the Ohio towns of Seven Mile, Bucyrus and Waynesville before graduating cum laude from Miami University with a Bachelor of Arts degree in Mathematics. Commissioned a second lieutenant through the ROTC program, he completed pre-flight training at Lackland AFB.

In September 1956, he entered UNT class 57-17, Harlingen AFB, Texas. Graduating at the top of his UNT class, Colonel Jones earned the first of several Distinguished Graduate honors that he has received over the years. He chose to continue training at Keesler AFB, Mississippi, in what was then the Air Force Electronic Countermeasures School. Colonel Jones again earned class honors and proceeded to his first operational assignment as a "Raven" in the EB-47 at Lockbourne AFB, Ohio, in April 1958.

After numerous deployments and nearly 500 hours in the EB-47 (much of it as an instructor), in early 1960 Colonel Jones volunteered for and was accepted into the newly forming B-58 Test Force. Arriving at Carswell AFB, Texas in April 1960, he was assigned to "Hustler" crew number four, and shortly thereafter he became a Standardization/Evaluation Defensive Systems Operator in SAC's 43rd Bomb Wing. He served in this capacity for three years, becoming one of the charter members of the Mach II club and participating in many of the early supersonic weapons drop and pod tests over the White Sands Missile Range. Transferring to an operations staff billet in late 1963, Colonel Jones worked as the 43rd Bomb Wing Performance Officer and DO Briefing Officer before departing for the Strategic Reconnaissance Directorate, HQ SAC, Offutt AFB, Nebraska in 1965. At SAC, he worked on the initial stages of the SR-71 reconnaissance program as well as the photo version of the B-58.

Colonel Jones attended Air Command and Staff College at Maxwell AFB, Alabama in 1967 and earned Distinguished Graduate honors. Next he volunteered for an assignment to Southeast Asia in the Wild Weasel F-105F. Accepted into the program that would eventually lead to his present assignment, Colonel Jones completed his "Thud" training at Nellis AFB, Nevada, and subsequently flew 113 combat missions with the 354th Tactical Fighter Squadron out of Takhli RTAFB, Thailand.

After Takhli, Colonel Jones chose a concurrent overseas tour with the Royal Air Force in the USAF/RAF Exchange Program. Assigned as an Electronic Warfare Staff Officer at RAF Medmenham, he completed several major radar and ECM studies for the Ministry of Defense, was a scheduled lecturer at all the RAF staff colleges, and edited the Royal Air Force Electronic Wartare Digest for the years 1969 and 1970. Airborne testing in the Vulcan and Canberra aircraft was another facet of Colonel Jones tour with the RAF, and airborne projects included trips to such varied locales as Cyprus, Germany, and the Outer Hebrides.

Coming home from the U.K. in 1971, Colonel Jones returned to the Wild Weasel force at Nellis AFB as an F-4C EWO Instructor in the 66th Fighter Weapons Squadron. He held this job throughout his tour at the 57th Fighter Weapons Wing despite the fact that his going-away plaque read "Lt Col at large." This title was well earned, for Colonel Jones, in his 2¾ years at Nellis, served as Commander of the 57th Services Squadron, Commander 57th Security Police Squadron, Chief of Electronic Warfare for Joint Exercise Exotic Dancer VI, and twice as the Wing Commander's Executive Officer. When asked about this potpourri of assignments, Colonel Jones says, "A great learning experience. After being in Operations, the Services and Security Police jobs were career broadners in the truest sense of the word; the Exec job put me at the center of the action on a daily basis; and my four months as part of the Exotic Dancer VI Control Team gave me an appreciation of the planning and preparation that go into a major exercise."

Colonel Jones departed Nellis AFB for the Air War College in July 1974. At AWC, he once again attained Distinguished Graduate honors while earning a Master of Arts degree from Auburn University with a straight A average. He then moved on to Bergstrom AFB, Texas, as Asst Chief of Logistics, 602d Tactical Air Control Group, before becoming Deputy Commander for Operations of the Wild Weasels in February 1976. As DO of the Weasels, Colonel Jones maintains EWO currency in the F-105G and enjoys going in the same Weasel flights as the "young guys just out of Mather." He says, "As a general rule, the EWOs we get straight from UNT and EWO training do a fine job. We're very proud of them in the Weasel program."

When queried on the secret of success as a navigator, Col Jones replied, "One shouldn't think of success as a navigator, EWO or pilot, but rather of success as an Air Force officer. That's where the secret lies. Do whatever job you have to the best of your ability, make your boss' day easier, be known as the man who always gets the job done, and you will be successful."

2

From The Editor

Loran C Update

Just after the Spring 1977 issue of *THE NAVIGATOR* was distributed, the U.S. Coast Guard notified Captain Ralph Van Wagner, author of "Coast in with Loran C," that some of the coding delays, previously announced, had been changed. It is unfortunate that this information was not available in time for our spring issue. For those of you whose equipment requires a coding delay, I hope the revised information will be useful and I am sorry for any inconvenience. The revised coding delays are:

Station	Function	Coding Delay
Middletown, CA	X9940	27,000
Searchlight, NV	Y9940	40,000
George, WA	Y5990	27,000
Shoal Cove, Annette, AK	Y7960	26,000

I need your help!

We are trying to build a complete set of back issues of *THE NAVIGATOR magazine*. The set will also include *THE NAVIGATOR magazine* predecessor *AIRCRAFT OBSERVER*. I have been unable to locate some of the issues and would like your help in finding them. If you would, please take a few minutes and look through those old boxes in the garage to see if you have any of the following:

AIRCRAFT OBSERVER

Volume I, No. 1, 1953
Volume I, No. 3, 1954
Volume II, No. 3, 1955
Volume II, No. 4, 1955
Volume III, No. 1, 1956
Volume III, No. 3, 1956
Volume III, No. 4, 1956

THE NAVIGATOR

Volume V, No. 2, 1958
Volume V, No. 3, 1958
Volume V, No. 4, 1958

Letters to the editor are encouraged and should be addressed to:

Editor, THE NAVIGATOR Magazine
323 FTW/DOTN
Bldg 3860, Stop 21A
Mather AFB, CA 95655

Reader Survey

We have had a tremendous response to the reader survey included in the Spring 1977 issue. A vast majority of you felt the magazine should be quarterly or monthly. Quarterly publication is under consideration if additional funds can be made available.

We find that many of you ask for more articles on certain weapon systems and specific jobs. Unfortunately, our only source for articles is the readership. An article on the job of an F-4 WSO can only be written by an F-4 WSO, and an EWO must write about the world of electronic warfare. In other words, there is a vast amount of untapped writing talent within the navigator force so why not take the time to draft an article on your job, a special nav trick you may have, your ideas on career opportunities, or some other topic that may be of interest to other navs. It's one way of proving your writing ability for your OER.

THE NAVIGATOR

AFRP 50-3, Volume XXIV, Number 2, Summer 1977

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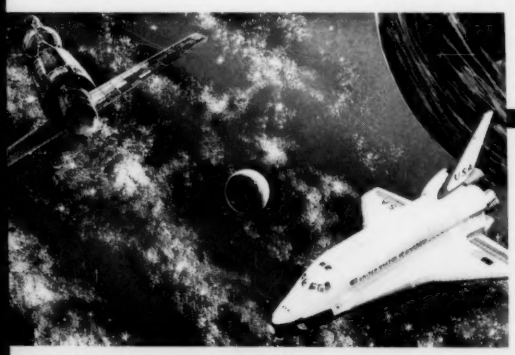


AFRP 50-3

The space shuttle and communications satellite on the cover highlight the thought-provoking feature on page 5, "Manual Space Celestial Positioning." This article presents the potential role of the navigator in space travel. A commonly used Marine navigation procedure, the noon fix, is described on page 19.

MANUAL SPACE CELESTIAL POSITIONING

Captain Alan R. Cobb
22d MAS
Travis AFB, CA

Artwork by
Ronald E. Martin
Napa, CA

Editor's Note: This article is intended as introductory information. Anyone desiring more in-depth knowledge on the theory involved may contact the author.

Navigation based on celestial positioning is as old as navigation itself. There have been many improvements in navigation procedures and celestial positioning since World War II. Automatic navigation (DR) computers for solving the wind triangle problem have made navigation more accurate and less time consuming. Now, according to some navigators, automation in the form of inertial navigation systems, automatic celestial trackers, and navigation satellites is going to make navigators obsolete. They cite, for example, the rumor that MAC may replace some navigators on their C-141s with a Doppler and a dual inertial navigation system. For this and similar reasons, some navigators are saying that the navigation profession will have no future in five to ten years. Not so! Man is always needed to monitor the system — too much reliance on automatic DR is dangerous to navs. As is the case with the advent of each new frontier, there are always a few who cry "the end of an era." Space travel, the new frontier, will bring a few more changes and a few new methods to an age old profession. The phases of a mission will no longer be called by familiar names but by new names as this comparison shows:

airship	spaceship
takeoff	liftoff
departure	planetary orbit
cruise	lunar, interplanetary, interstellar, etc., trajectory
arrival	planetary orbit
approach	re-entry
landing	splash down (water)
landing	landing (terrain)

Almost every activity taking place within the spaceship will be controlled or monitored by several on-board computers. One of the primary tasks will be guidance and control of the spaceship. This will involve not only inertial

systems and radar ranging from nearby planets but also celestial positioning. The celestial positioning will probably be accomplished by automatic celestial trackers similar to today's version but more complex. Monitoring the accuracy of those celestial trackers and updating them when they err will be but a part of the astronaut-navigator's (or astrogator's) job. If the trackers have a complete failure or require updating, then the astrogator could use a celestial positioning method (possibly manual) as a backup. In order to show the similarities between the manual positioning methods of current navigators and future astrogators, I will first present a brief refresher on Earth oriented celestial positioning theory before developing space oriented celestial positioning theory.

In Earth oriented celestial theory, the Earth is assumed to be a perfect sphere located at the center of an imaginary sphere of infinite radius called the celestial sphere. It is assumed that all of the celestial bodies except the moon are located on this imaginary sphere and all light rays incident on earth are parallel. This is assumed because the distance to Alpha Centauri, the nearest celestial body outside of our solar system, is approximately 2.87 trillion times the distance to the Earth from the aircraft (at 50,000 feet). In order to establish a coordinate reference system on the celestial sphere, the Earth's True North and True South Poles and equator are projected upon it and called the celestial poles and celestial equator (or equinoctial) (Figure 1). The Earth's latitudes and longitudes are also projected upon the sphere. The position of a celestial body on the celestial sphere is measured along the projected latitudes either north or south of the celestial equator and called the Declination (Dec) of the body. A fixed reference point on the celestial equator is used to determine the position of bodies on the equator. This point is the Vernal Equinox which is also called the first point of Aries (♈). It is the point where the Sun's apparent path around the celestial sphere (called the ecliptic) crosses the celestial equator as from southerly to northerly declinations. The angle measured westward along the celestial equator from Aries to the celestial body is called the Sidereal Hour Angle (SHA) for that body (Figure 1). The observer's position or Zenith ($\mathring{\nabla}$) is located by his latitude and longitude coordinates and then projected upon the celestial sphere. Since the observer's longitude is measured from the Greenwich Meridian while the SHA of the body is measured from Aries, it is necessary to define Aries with

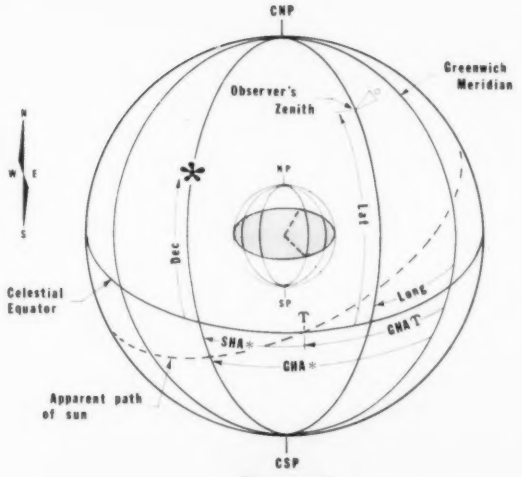


Figure 1

respect to the Greenwich Meridian. The angle measured westward from the Greenwich Meridian to Aries is called the Greenwich Hour Angle (GHA) of Aries (Figure 1). The celestial body position can then be located from the Greenwich Meridian by adding the SHA of the body to the GHA of Aries and is called the GHA of the body, i.e., GHA* = SHA* + GHA*. All of the bodies within our Solar System can be located upon the celestial sphere using their individual GHAs and Decs as published in the Air Almanac. A spherical triangle, whose vertices are the Celestial North Pole, the observer's zenith, and the body's position, can be constructed upon the celestial sphere.

This spherical triangle, called the Celestial Triangle, is constructed by connecting the vertices as shown in Figures 2a and 2b. The side of the triangle between the Celestial North Pole (CNP) and the body's position is equal to 90 - Dec or Co-Dec. The side from the CNP to the observer's position is the Co-Lat and equals 90 - Lat. The smallest angle at the CNP between the Co-Lat and the Co-Dec, is called the interior angle Alpha (α). The angle at the CNP measured westward from the Co-Lat to the Co-Dec is the Local Hour Angle (LHA) of the body and may equal Alpha (Figures 2a and 2b). To compute Alpha, first compute the LHA* by subtracting West Long * from or adding East Long to the GHA*, i.e., LHA* = GHA* + West/-East Long*. If the observer's position is east of the body's position, then the LHA is equal to Alpha (Figure 2a). If the observer's position is west of the body's position, then subtract the LHA from 360 to get Alpha (Figure 2b). Using the Lat, Dec, and Alpha, the altitude (Alt) of the body above the observer's

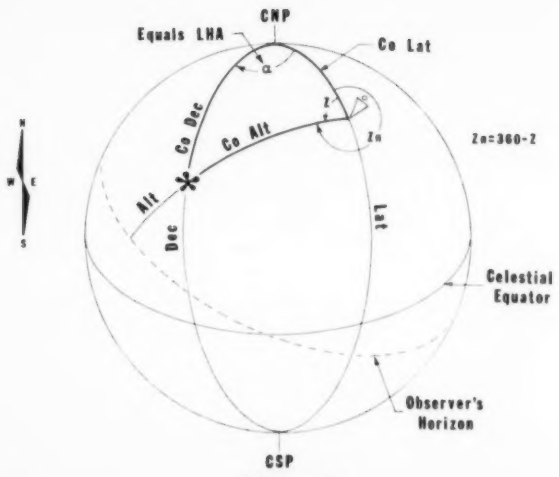


Figure 2a

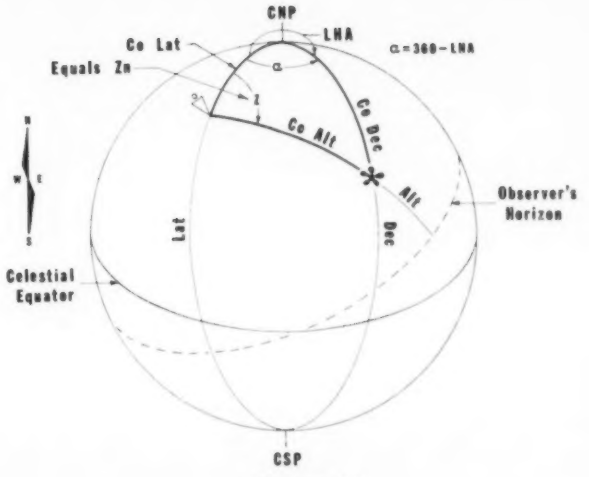


Figure 2b

horizon can be determined. Most navigators refer to the altitude of the body as the computed height (Hc) when it is based on an observer's assumed latitude and longitude for a future time and as the observed height (Ho) when it is measured at the observer's actual position.

Another useful quantity that can be obtained from the information known is the interior angle, called the azimuth (Z) of the body, measured from the Co-Lat towards the Co-Alt (= 90 - Alt) at the observer's position. Once the azimuth of the body is known, the true azimuth (Zn) of the body (angle measured clockwise from true North to the body) can be calculated from the following formulas (using Ho 249):

> If the LHA was greater than 180 (LHA > 180), then Zn = 360 - Z
> If the LHA was less than 180 (LHA < 180), then Zn = Z

The determination of the Hc and Zn of a body is accomplished by most navigators with H.O. 249 Volumes which contain completed celestial triangle solutions. (The trigonometric equations used to compute Hc and Z, either manually or with the aid of a hand-held computer, are listed at the end of this article.)

Now that the Hc and Zn of the body are known, an observation of the body's altitude above the observer's horizon can be taken using a hand-held, D-1, or automatic sextant to compare with the computed altitude (Hc). The observed altitude or Ho of the body, when converted to a Co-altitude, defines a circle of equal altitude on the Earth upon which the observer's position is located. The center of the circle is the subpoint of the body. The computed altitude or Hc defines another circle of equal altitude upon which the observer's assumed position is located. To determine the observer's actual position, it is necessary to know the direction (Zn) of the body's subpoint from the observer's assumed position and the distance away from that assumed position. The Zn has been computed and the difference between the observer's actual and assumed position is equal to Ho ± Hc in nautical miles. If the Ho is greater than the Hc (Ho > Hc), then the actual position is closer to (towards) the body's Zn. If the Ho is less than the Hc (Ho < Hc), then the actual position is farther (away) from the body's Zn. The distance is measured, starting from the assumed position, either towards or away from the Zn of the body and a Line of Position (LOP) is plotted at this distance perpendicular to the Zn. The navigator now knows his position is located somewhere on this LOP and to further identify his exact position, he must perform one, or preferably two, more calculations and sightings of other bodies with Zns about 120 degrees from that of the first body. If desired, more LOPs may be obtained to increase the accuracy of the position. Corrections must be applied to the Ho to compensate for errors such as coriolis (which is very important) due to earth rotation, and refraction (bending) of the light rays from the body as they penetrate the Earth's atmosphere. These corrections do not alter the basic theory but only correct the observation to make it more accurate.

We have reviewed Earth oriented celestial positioning theory. Now let's explore space oriented celestial positioning theory. Although similar to Earth celestial theory, space celestial theory presents a more difficult solution because

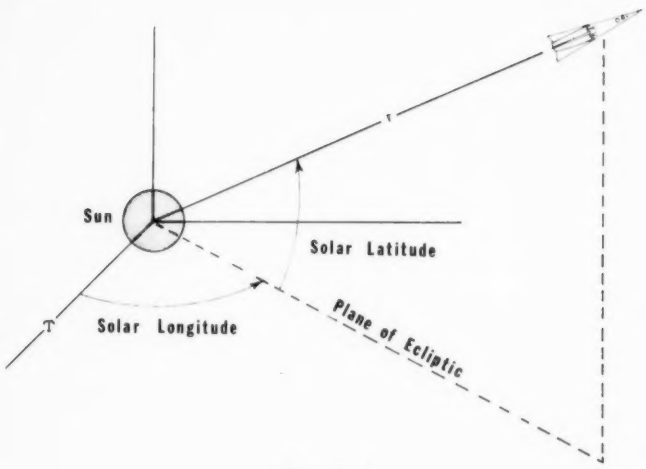


Figure 3

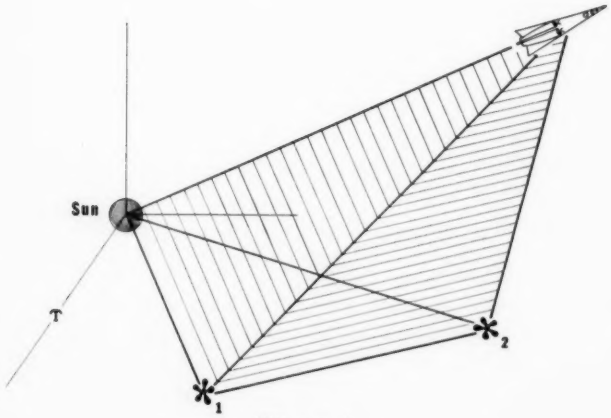


Figure 4

the distance from the spaceship to the coordinate reference system may not be insignificant when compared to the distance from the spaceship to the nearest body being observed. For example: In space oriented celestial theory the distance from a spaceship to the center of the sun is 400,000 miles and to Saturn is 500,000 miles. In Earth oriented celestial theory the distance from an aircraft to the center of the Earth is 9 miles and to Saturn is 850,000 miles.

Thus a convenient coordinate reference system is chosen to describe the positions of the observed bodies and the spaceship. Using the Sun as the center of the coordinate system and referencing all bodies from it is easiest for interplanetary flight but not for intragalactic travel. The center of the galaxy would be used to reference all bodies for intragalactic travel. The next frontier in space for the navigator, as I foresee it, will be navigating interplanetary shuttles. Thus I will discuss manual space celestial positioning as it would pertain to interplanetary flight. The same solution would apply to intragalactic flights if the coordinate reference system was mathematically translated and rotated to a reference system located at the galactic center.

A coordinate system for interplanetary flight may be defined by projecting the ecliptic plane into space and using the line from the Sun to Aries as a reference line. Two angles and a radial distance (distance from coordinate system to body) will locate any point around the Sun in this system (Figure 3). The Solar Longitude (S. Long) is measured counter-clockwise from the reference line and the Solar Latitude (S. Lat) is measured either north or south from the plane of the Solar Ecliptic. S. Lat is a positive number if measured northward and a negative number if measured southward. The final quantity needed to locate a point is the radial distance (r) of the point measured from the center of the Sun. S. Long, S. Lat, and the radial distance for each navigational body could be computed and published as is done currently in the Air Almanac for the SHA and Dec of each star.

As in Earth oriented celestial positioning, observations of two or more bodies are required to determine the spaceship's position, but only one set of calculations is necessary. These calculations are derived from trigonometry and the geometry of the figure formed by the Sun, the two observed bodies, and the spaceship. The three dimensional figure appears to be a lopsided pyramid with the Sun and observed bodies at its corners and the spaceship at its apex (Figure 4). In addition to the S. Lat, S. Long, and radial distance that are known for each star, the angle

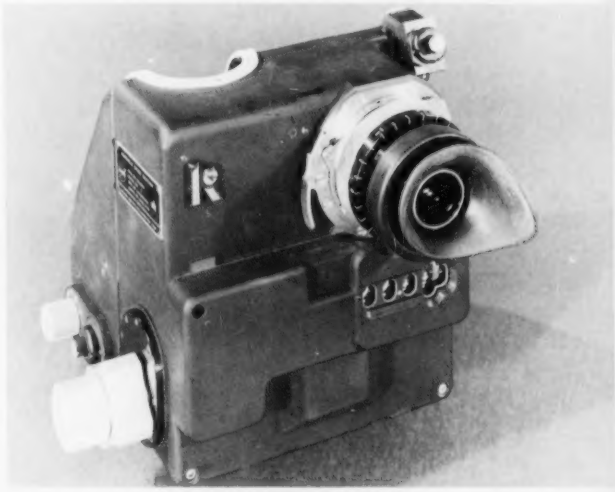


Figure 5

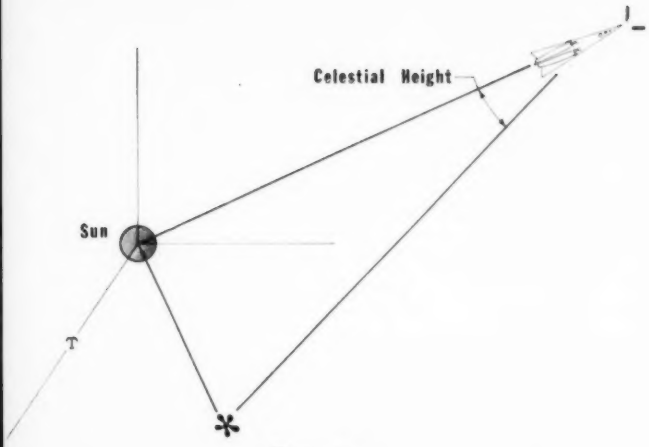


Figure 6

between the Sun and each star as seen from the spaceship must be measured.

The measurement of these angles is accomplished by the astrogator with the aid of a hand-held space sextant (Figure 5). The space sextant works in a manner similar to the mariner's sextant by superimposing the observed body and a reference body (in this case the Sun). The counter dial reading is the desired angle between the Sun and the body as observed from the spaceship and shall be called the Celestial Height (CH) (Figure 6). One reading of each star for identical times is necessary to accomplish the calculations. In order to obtain both readings for the same time, take one reading of each star for an equal time period before and after the desired position time and average the readings. For example: Star 1—8 minutes before and after, Star 2—4 minutes before and after, and then average Star 1 readings for CH1 and Star 2 readings for CH2.

With the S. Lat, S. Long, CH, and radial distance known for each star, the radial distance of the spaceship from the Sun can be calculated. Once the radial distance of the spaceship is obtained, the S. Lat and S. Long necessary to complete the location of the spaceship can be computed. The computations to determine the S. Lat, S. Long, and radial distance of the spaceship are a set of six complicated equations involving trigonometry. (They are listed at the end of this article for those desiring them.) With these quantities computed, the position of the spaceship is located and the astrogator's celestial positioning problem is solved. No plotting is necessary in this method since the onboard computer can use those quantities to update its position. Additionally, the plotting would have to be done within the volume of a sphere representing the area of space being flown in and would require too much room within the spaceship.

Most navigators compute Earth oriented celestial positioning manually with a set of completed celestial triangle solutions but a computer can be used if desired. Space oriented celestial positioning could be computed manually if a set of completed solutions was published but this material would be impractical to carry on board because of the weight and space required. The onboard computer can solve this problem.

As is true of the majority of today's navigators, the astrogator of the future will have to work with computers to accomplish his job. This does not mean that navigators will be replaced by computers. Man will always be required to check the accuracy and correct the errors of the computer. This is a part of the future for the navigation profession as I foresee it.

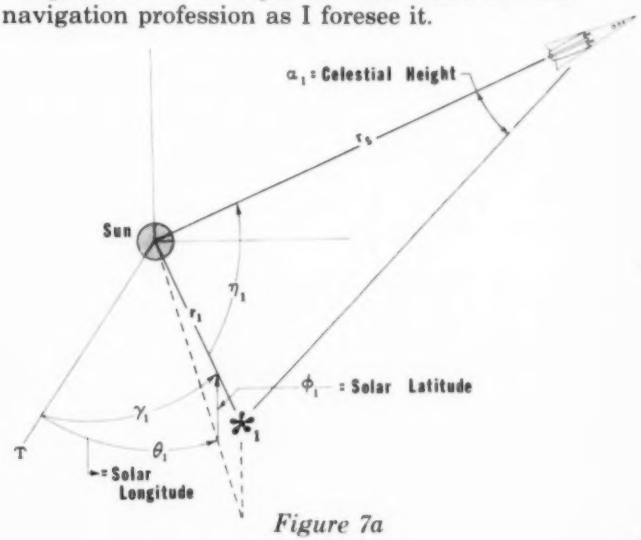


Figure 7a

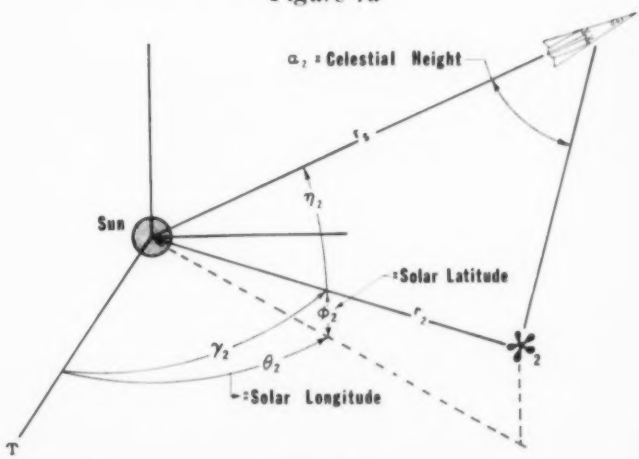


Figure 7b

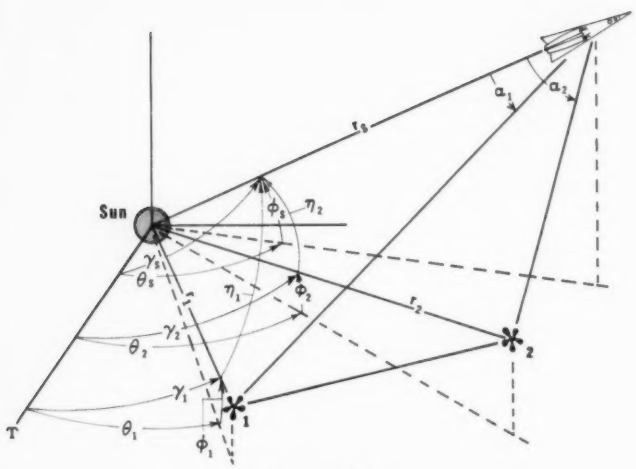


Figure 7c

Earth oriented celestial positioning equations (Refer to Figures 1 and 2)

$$H_c = \text{Sin}^{-1}\left[\text{SIN(Lat)Sin(Dec)} + \text{Cos}(\alpha)\text{Cos(Dec)Cos(Lat)}\right]$$

$$Z = \text{Cos}^{-1}\left[\frac{\text{Sin(Dec)} - \text{Sin(Lat)Sin(Hc)}}{\text{Cos(Hc)Cos(Lat)}}\right]$$

If the LHA was greater than 180 (LHA > 180), then Zn = 360 - Z

If the LHA was less than 180 (LHA < 180), then Zn = Z.

Space oriented celestial positioning equations (Refer to Figures 7a, 7b, and 7c

$$r_s = \frac{r_1 r_2 \text{Sin}(\alpha_1 - \gamma_1 - \alpha_2 + \gamma_2)}{\left[r_2^2\text{Sin}^2(\alpha_1) + r_1^2\text{Sin}^2(\alpha_2) - 2r_1 r_2 \text{Sin}(\alpha_1)\text{Sin}(\alpha_2)\text{Cos}(\alpha_1 - \gamma_1 - \alpha_2 + \gamma_2)\right]^{1/2}}$$

$$\eta_1 = \text{Sin}^{-1}\left[\frac{r_s \text{Sin}(\alpha_1)}{r_1}\right] - \alpha_1$$

$$\eta_2 = \text{Sin}^{-1}\left[\frac{r_s \text{Sin}(\alpha_2)}{r_2}\right] - \alpha_2$$

$$\phi_s = \text{Tan}^{-1}\left[\frac{\text{Cos}(\eta_1 - \theta_1)\text{Cos}(\eta_2) - \text{Cos}(\eta_2 - \theta_2)\text{Cos}(\eta_1)}{\text{Cos}(\eta_1)\left[\text{Sin}(\phi_2) - \text{Sin}(\eta_2 - \phi_2)\right] - \text{Cos}(\eta_2)\left[\text{Sin}(\phi_1) - \text{Sin}(\eta_1 - \phi_1)\right]}\right]$$

$$\gamma_s = \text{Tan}^{-1}\left[\frac{r_1\text{Sin}(\alpha_2)\text{Sin}(\alpha_1 - \gamma_1) - r_2\text{Sin}(\alpha_1)\text{Sin}(\alpha_2 - \gamma_2)}{r_2\text{Sin}(\alpha_1)\text{Cos}(\alpha_2 - \gamma_2) - r_1\text{Sin}(\alpha_2)\text{Cos}(\alpha_1 - \gamma_1)}\right]$$

$$\theta_s = \gamma_s + \phi_s$$

$$\gamma_1 = \theta_1 - \phi_1$$

$$\gamma_2 = \theta_2 - \phi_2$$

If desired, the following references will aid you in further research on this subject:

1. Allen, W.H. (ed), *Dictionary of Technical Terms for Aerospace Use*; Scientific and Technical Information Division, NASA, 1965

2. Corliss, W., *Space Probes and Planetary Exploration*; D. Van Nostrand Company, Inc., 1965

3. Dunlap, G.D., and H.H. Shufeldt, *Dutton's Navigation and Piloting*; United States Naval Institute, 1969

4. Glasstone, S., *Sourcebook on the Space Sciences*; D. Van Nostrand Company, Inc., 1965

5. Haviland, R.P., and C.M. House *Celestial Navigation in Space*; from: *Advances in Astronautical Sciences*, Vol 13, 1963

6. Hunter, C.D., *Air Force Manual Space Navigation*; Space and Missile Systems Organization, 1972

7. Hymoff, E., *Guidance and Control of Spacecraft*; Holt, Rinehart, and Winston, 1966

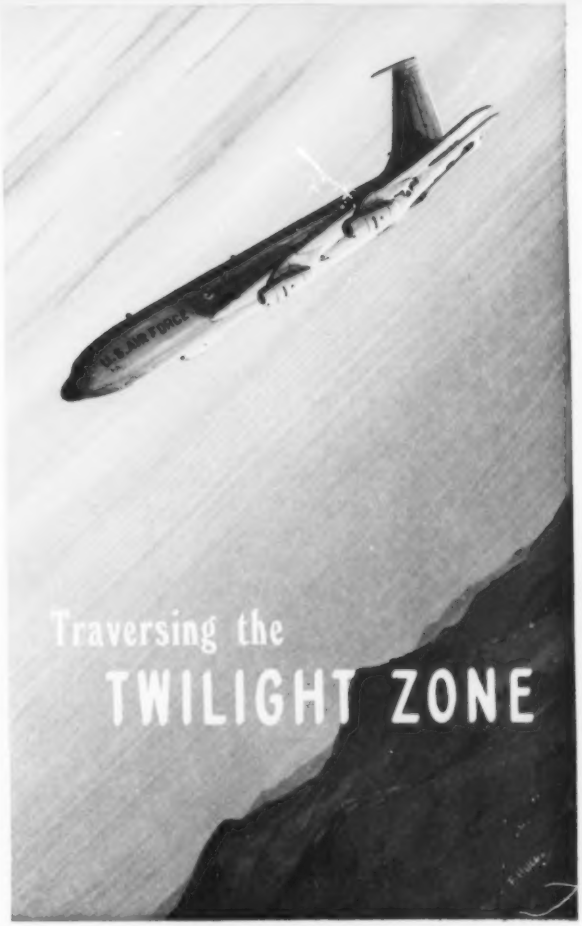
8. Oliver, E.F., *Interplanetary Navigation*; from: *Journal of The Institute of Navigation*, Vol 10, 1964

9. Park, R.A., and T. Magness, *Interplanetary Navigation*; Holt, Rinehart, and Winston, 1964

10. Stearns, E.V.B., *Navigation and Guidance in Space*; Prentice-Hall, Inc., 1963

Captain Cobb received his BS in Physics from the University of Missouri at Rolla. Commissioned through OTS in 1969, he subsequently completed UNT in August 1970. He then flew EC-47s in Vietnam and earned four air medals and the DFC. From Oct 71 to Sep 75, he served as a UNT instructor followed by his present assignment flying C-5 aircraft with the 22d Military Airlift Squadron at Travis AFB.

1st Lt Glenn Frazho
11 AREFS
Altus AFB, OK



Twilight conditions encountered during flight have often caused even the well planned nav leg to go amiss. Study of nav legs in pre-dawn or early evenings emphasizes the need for total awareness of the twilight band. It is extremely important to be able to predict where and when twilight will be encountered during flight because these conditions are important to the celestial observations and pacing requirements of navigation.

Twilight may be defined as that period before sunrise or after sunset when the observer sees sunlight reflected from the atmosphere. There are three types of twilight: astronomical, civil, and nautical. Civil twilight most concerns the navigator because the sun has set but reflected light prevents observation of other celestial bodies.

Sunrise and sunset at sea level occur when the upper limb of the sun is horizontal with the natural horizon of the observer. At this time the depression angle of the sun is 0.8°. (Depression angle is that angle measured from the center of the celestial body below the natural horizon at sea level to the horizon itself.) For an observer above sea level sunrise will occur earlier and sunset later than that at sea level. Similarly, the beginning or end of civil twilight occurs when the depression angle of the sun is 6.0° at sea level and increases with the height of the observer. This information may be obtained by consulting Air Almanac tables 2 and 3 of the Rising, Setting and Depression Graphs.

To compute twilight for an observer located at 40° N and 83° W at an altitude of 25,000 on 12 August 1975 we must consult table 1, Meridian Passage And Declination of the Sun at 12 GMT of the Rising, Setting and Depression Graphs. From this we find that meridian passage for an observer at any longitude will be 1205 LMT at a declination of N 15.1 (declination of the Sun at 1205 GMT/12 August 1975).

With this information enter the Rising, Setting and Depression Graphs for the corresponding latitude; in this example 40 N. Depression angles are read vertically on the left side of the graph and diagonal lines represent declination.

Enter the graph at depression angle 3.9 for sunrise at 25,000 (from table 2) and go across to N 15.1. From this intersection read vertically for a value of 7 hours and 15 minutes. This value will be subtracted from 1205 LMT for sunrise or added for sunset. In this case sunrise will occur at 0450 LMT.

Table 1

DR LAT DR LONG	39-50N 82-55W		37-50N 86-40W		35-25N 90-30W		32-50N 94-15W		30-10N 98-00W	
DEPRESSION OF SUN	3.9 SR	6.8 BCT	3.9 SR	6.8 BCT	3.9 SR	6.8 BCT	3.9 SR	6.8 BCT	3.9 SR	6.8 BCT
MERIDIAN PASSAGE (L)	1205	1205	1205	1205	1205	1205	1205	1205	1205	1205
HOUR ANGLE	-7:15	-7:30	-7:10	-7:26	-7:03	-7:20	-6:58	-7:15	-6:53	-7:10
LMT	0450	0435	0455	0439	0502	0445	0507	0450	0512	0455
CONVERSION	05:32	5:32	5:46	5:46	6:02	6:02	6:16	6:16	6:30	6:30
GMT	1022	1007	1041	1025	1104	1047	1123	1106	1142	1125
ETA Z	0930Z		1010Z		1050Z		1130Z		1210Z	

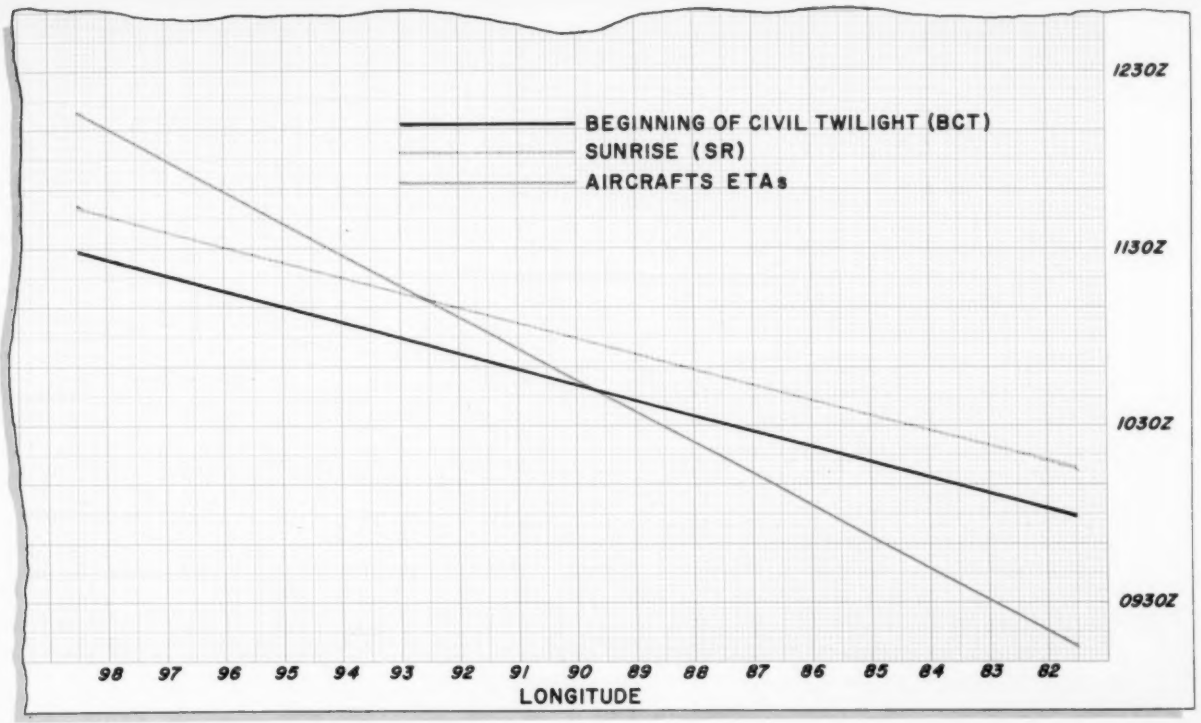


Figure 1

Since we are concerned with twilight we again repeat the same procedure for computing the beginning of morning twilight. The depression angle at twilight at 25,000′ is 6.8 (table 3). Entering the Rising Graphs at the same latitude we come up with a value of 7 hours and 30 minutes. Subtracting this value from 1205 LMT we arrive at the beginning of morning twilight at 0435 LMT.

Since all times thus far have been LMT it is necessary to convert these figures into GMT. To do this, take the longitude of 83° W and enter the Conversion of Arc to Time Table (also in the Air Almanac). The 83° arc converts to 5 hours and 32 minutes. Add this figure to all LMTs to arrive at GMT. If east longitude were given the value would be subtracted from LMT.

Probably the most commonly used method of twilight planning is the graphic interception. This method helps the navigator visualize the time, place, and duration of twilight during flight. The following problem illustrates this method: A navigator plans a flight in a KC-135 from Rickenbacker AFB to Bergstrom AFB on 12 August 1975, with T.O. 0930, altitude 25,000′, TC 230 and GS 360.

1. Determine appropriate longitudes along the flight planned route. In this example the navigator selects every 40 minutes. (Use latitude if more convenient.)

2. Compute the GMT of the beginning of morning twilight and sunrise at each of the positions selected.

3. Construct a graph showing the twilight band. Use the vertical axis for GMT, and the horizontal axis for longitude coordinates. The twilight band is plotted with time and longitude.

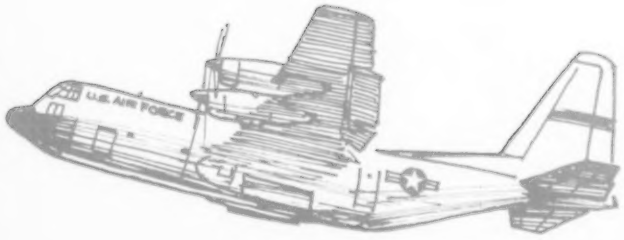
4. Using planned groundspeeds, establish ETAs to the points. Plot these on the graph.

5. The graphic interceptions show the navigator will encounter twilight at 1040Z when he is at 89-40 W. Sunrise will occur at 1115Z at a longitude of 93-00W (35 minutes of twilight conditions).

By using this method of planning a navigator can traverse the twilight band with relative ease. He will be able to predict twilight and adjust the pacing of celestial observations around it.

Lt Frazho, a native of Dunedin, Florida, completed navigator training at Mather AFB in 1973. He then attended the KC-135 Combat Crew Training School at Castle AFB. Since then, Lt Frazho has been assigned as a crew member with the 11th Air Refueling Squadron, Altus AFB.

Navigation - US vs Europe



First Lieutenant Robert L. McCarty
773d TAS
Dyess AFB, TX

I would like to state first that I'm not going to write as if I'm experienced in European navigation because I'm not. If I were, I probably wouldn't be writing this article. I'm writing it to show some of the difficulties and differences I found between navigating in the United States and in Europe. Because I was a new navigator, I would like to direct this article at other new navigators who may find this helpful in letting you know what to expect. I'm not saying that this article isn't for the navigator who has been over there. You navigators with minimal time may be able to relate some of your experiences to what I have to say, while you experienced ones may just find this article interesting, if not amusing.

To begin with I went over to Europe not totally prepared for what was going to happen. It wasn't anybody's fault but my own that this occurred. I went over thinking that the European airway system was like that of the States. Who would have thought differently? Surely they have as advanced a radar network as we do and nearly as much air traffic, so why should it not be the same? That was my first mistake, and it wouldn't be the last. The major thing I didn't take into account was that Europe is made up of different countries with governments that really don't think alike and who like to run their airspace their own way.

Unlike the U.S. airway system where you can file to the airway you want and the navigator can relax a little—in Europe getting from Point A to B isn't so easy. You have to contend with such things as controllers whom you can't understand, one-way airways, airways on which you must fly in certain directions and at certain altitudes (which don't always agree with the hemispherical separation rule) and Tacan routes which require prior permission to use. Each of these will be discussed more fully.

By taking an imaginary trip from Rhein-Main AB in Frankfurt, Germany, to Zaragoza AB, Spain,I can show you all the little headaches and problems that could arise. The first thing to do

when you know where you are going is to plan the flight. After determining that Zaragoza is truly in Spain and that Spain is south of Germany, you need to pick a standard instrument departure, or SID. Unlike the States you just can't request radar vectors to intercept your airway. The Europeans believe that SIDs were set up for a certain reason and that you should use them.

Next you start to realize that the altitude at which the high altitude structure begins varies from country to country. It is not the wonderful, solid 18,000 feet it is back in the States. The altitude can vary anywhere from FL195 to FL250 depending upon where you are. If your aircraft (such as the C-130E) can't fly high enough to stay in the upper airways structure you find yourself continuously jumping back and forth between the high and low enroute charts.

Well, anyway, our SID takes us to where we can pick up our desired airway provided we stay below FL195 since both Belgian and French high altitude structures start there. By studying the charts we realize that it is advantageous to stay low because we can get better routing. Later we can go to the high structure for more direct routing and fewer reporting points.

In picking your route you next find that the ADF, which you thought was only good for listening to the radio, is a major navigational aid in Europe. To make matters worse there are four different types of stations which require different tuning methods. So you quickly take a crash course in ADF tuning for the times that these stations are the primary airway positioning aids.

Now that you are headed in the right direction, you notice that some of the airways have arrows pointing in only one direction. Others have little As or Bs with arrows pointing in one direction, and still others have a T designation on the name instead of the normal U (for upper airway). The ones with the big arrows are one-way airways. Don't try to file or plan in the opposite direction—it doesn't work and somebody usually gets mad. The little As and Bs are the altitude designation mentioned earlier and can be found on the front of the chart. Some may specify an altitude differing from the hemispherical separation rule. For example, in France there are several airways where you are heading west at FL210,230,etc.,and east at FL220, 240, etc. That airway with the funny T designation is a Tacan route to be used by Tacan-only equipped aircraft. If you have an operational VOR don't file on that airway. For us in the old C-130 it didn't matter since in France the Tacan routes started at FL260 and we couldn't get that high with a full load.

After you've finally planned through France and are flying along your upper airway at FL210, where most missions are flown, you come to Spain. Spain's upper airway system starts at FL250, so you must plan your section of flight in Spain in the low structure. Going from the high to the low or vice versa between Spain and France, your airway ends with no connecting airways which means you must file direct to another airway. This is one of the few times you can file direct, based on my experience, since it seems that the Europeans would rather have you use an airway if at all possible.

Finally, you get to Zaragoza and choose your approach. Now you should review FLIP to check every country you fly through to make sure you have done everything correctly and to check the restrictions on the airways. Here you can find out if you need prior permission to use an airway. Nothing is more embarrassing than to hand your aircraft commander a complete flight plan only to find that according to FLIP you can't use one of the chosen airways.

The final thing you do to your flight plan is figure your time enroute and your estimates to the various FIRs based on your scheduled takeoff time. These times, along with the FIRs, go on the DD Form 1801, International Flight Plan, with your intended route of flight. As the navigator, you must make sure these times are correct.

Now that everything has been checked and you have filed, it's time to fly. At Frankfurt, after equipment check out, you and the copilot listen to the Automatic Terminal Information Service, or ATIS, for weather, runway in use, transition level, pressure, IFF/SIF, squawk, etc., because the control tower will expect you to have this information when you request taxi instructions. The first problem you'll encounter is trying to understand them. Once you've started to overcome this problem you'll run into the next. That is trying to understand the information. Even though it is given in a certain sequence you'll probably miss most of the information the first couple of times because you're not sure what you heard and because it comes a little fast. You'll encounter little surprises such as receiving the ceiling in octaves, or eighths of the sky obscured, rather than the more familiar scattered, broken, etc. Also, the pressure is given in millibars, which causes a mad rush to the enroute supplement for the conversion to inches of Mercury. After much

listening and some concentration you may get most of it. If you have difficulty the first time don't be alarmed, it takes time to get used to it. Some people who have been to Europe several times comment on how hard it is to understand the ATIS.

Now that you have all this information you request taxi instructions to the active runway. Once there you do your run up and ask for release for takeoff. Once you takeoff your work isn't over even though this is only an airway mission. The Germans have a different concept on how to fly a SID than we do in the States. Usually we just let the pilot fly the SID the best he can and we back him up. If he gets a mile or so off it doesn't make a lot of difference. In Europe it's different, especially flying out of Frankfurt. You have to maintain that SID track to the best of your ability due to the Germans' big concern for noise abatement. Don't let the pilot wander, let him know when he is a half mile off course. It doesn't take much to set off one of the numerous sensors along your track.

Next, things will happen fast. The pilot will ask for an estimate to your next check point. While you are computing the ETA, the pilot calls transition level and changes to 29.92; but you are only at 5,000 feet. Has the pilot gone crazy as you always suspected? No, he hasn't. In Europe, countries have different altitudes where you change over to pressure. If you had been listening closely to the ATIS you would have known it. The pilot will continuously need ETAs to each check point. Also, you will find that when flying through countries like France, you may not end up going in the direction you planned. Sometimes they'll send you on a more direct course to help save time, and then there are times when you may get to see the countryside. French controllers also will usually only clear you to your next check point instead of clearing you for your complete route. Once you reach your check point you may sometimes have to ask where they want you to go next, and sometimes what they tell you may not be in the direction you're headed. So be ready to come up with a heading and estimate to that next point quickly. This was how I spent part of my time over France, trying to figure out where we would be sent next. Once a French controller cleared us to a point I simply couldn't find on the high charts. We finally found it on the lows. They didn't want us to go down. They simply cleared us to a point where the high and low airways coincided.

You will find it hard at times to understand the controllers. One reason is because of their accents. They also use phonetic identifiers instead of full names, and sometimes when they clear you to several points all those letters get a little confusing. Don't get me wrong, the controllers in Europe are good; they have to be.

On your descent you will get the local altimeter setting and change over at the proper transition altitude (TA) as shown in the approach book. The transition altitude is like the transition level in that it is not at 18,000 feet. But the transition altitude doesn't have to equal the transition level. For Zaragoza AB the TA is 5,000 feet.

After all this you finally get lined up, shoot your approach, land, taxi in, and shut down. You made it, your first ride in Europe and you've survived. You didn't have a mid-air or any other disaster. Now you unload and get ready to do it all over again.

These are just some of the things you'll find different in Europe. There are others which you will find out about as you fly in the different countries and talk to the more experienced navigators. There will be times when a controller on a precision approach will tell the pilot when he is only feet off course, and then there are times when a controller will get mad at you and won't talk to you at all, which is not so good.

In conclusion, I'd like to say don't let this article scare you about flying in Europe, because after you have had several rides everything will come naturally and things will move along smoothly. If you make a mistake don't worry because all new navigators make them. Europe was a very valuable experience for me in introducing me to ICAO rules and regulations. I enjoyed Europe and navigating through it and I'm sure all you new navigators will when your time comes.

1st Lt McCarty graduated from Purdue University in May 1974. He then entered navigator training at Mather AFB and graduated in May 1975. Since then, Lt McCarty has been assigned to the 773d Tactical Airlift Squadron, Dyess AFB, flying the C-130H.

Choosing an ASSUMED

Captain Patrick L. Campbell
379th BMW/DOT
Wurtsmith AFB, MI

A commonly accepted celestial navigation belief is that choice of an assumed position has little or no bearing on shot accuracy. Frequently we choose the assumed position nearest the intended fix to make plotting easier. Likewise, when considering combined motions, many navigators favor multiplying the smallest combined adjust by the largest increment of time. They believe this system will make results small and manageable.

Because these techniques are commonly accepted is no license for them to be correct. In fact, they can cause a boondoggle LOP. They are a myth whose time has come.

Let me illustrate with a situation. An aircraft flying eastbound in the jetstream near 45°N is making good a 510 kt GS (Figure 1). At this rate it will cross 12 meridians of longitude per hour. The celestial sphere is moving in the opposite direction at 15 meridians of longitude per hour. They combine to give an effective change of 27° LHA per hour. You select an assumed position 6 minutes longitude down track and 30 nm offset from your intended fix. The star with the smallest combined adjust has Hc =62° and ZN =180; in fact, the combined adjust is 0. You shoot it 12 minutes early and are surprised to get a course line LOP 22 nm away from your good DR. Let's find out what went wrong.

1. During the 12 minutes since you shot the LOP the aircraft flew thru a 5.4° LHA change (27°/hr X .2 hr = 5.4°). With the assumed position another .1° down track from your DR there was a 5.5° discrepancy between assumed and shot time LHA.
2. The star you shot 12 minutes early produces a course line LOP at transit. At 62° altitude a 1° change in LHA equates to a 2° change in ZN. Assumed ZN and actual shot time ZN differ by fully 11°.
3. At 510 knots 11° ZN error causes a 19½ nm motion of the observer error.
4. Not using individual LHAs costs 2 nm for motion of the body error.
5. Finally, the 11° ZN error causes a ½ nm plotting error.

The situation improves considerably for day celestial because time dependent inaccuracies have less time to grow. Using the same situation as with the star except shooting 9, 6, and 3 minutes early we find:

LHA Discrepancy = 2.8° (Use 6 min early mid time shot.)
ZN Discrepancy = 5.6°
Motion of the Observer Error = 5 nm
Motion of the Body and Plotting Errors = 5 nm

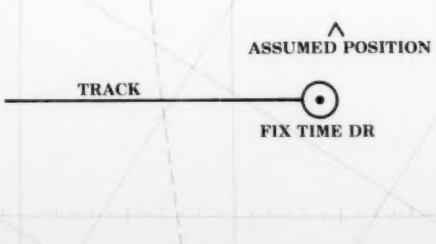
By far, motion of the observer takes the lion's share of the error. Since it is so sensitive to small changes for course line LOPs, we require a new approach to selecting stars and assumed positions.

THE IDEAL ASSUMED POSITION. Only one assumed position is best suited to resolving an LOP. I call it the ideal assumed position because: (1) plotting distances are reasonable, (2) assumed ZN = shot time ZN, and (3) a zero intercept passes thru planned fix time DR.

To construct the ideal assumed position draw a ZN line thru the aircraft shot time postion. At any

ILLUSTRATION

Figure 1



IDEAL ASSUMED POSITION

Figure 2

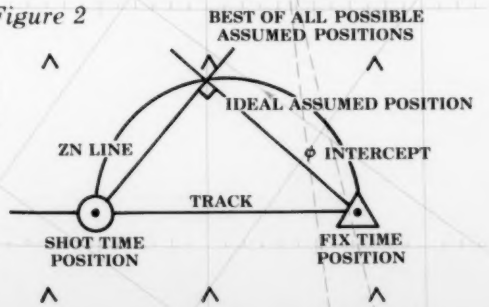


Figure 3

point along that line the ZN to the star is the same (Figure 2). Next, draw a perpendicular to the ZN line so that it passes the fix time DR. This perpendicular is a line of equal intercept; moreover, that intercept is zero. The right angle where the two lines cross is the ideal assumed position. Through geometry you can determine that if the hypotenuse of a right triangle is the diameter of a circle, then the right angle lies on the circumference. The usefulness of this property is that:

The ideal assumed position lies on the circumference of a circle whose diameter is the shot time to fix time track.

Looking at Figure 3 below we can draw the following conclusions:

1. A course line LOP's ideal assumed position lies near shot time DR.

2. A speed line LOP's ideal assumed postion lies near fix time DR.

3. An intermediate line LOP's ideal assumed position is half the shot time to fix time interval and an equal distance left or right of track.

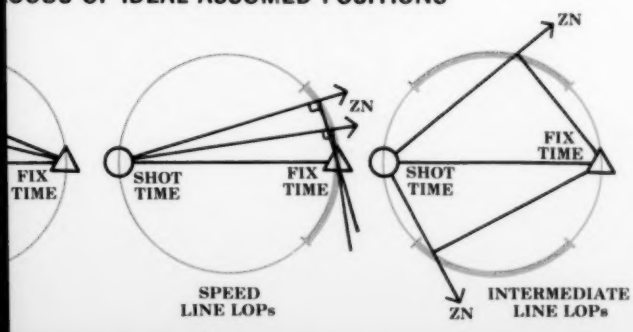
The above three rules of thumb can be applied to day celestial navigation with relative ease. Although you may be plotting 50 to 60 nm from the point of intended fix (course line LOP), the ZN will be accurate and the intercept small.

For night celestial navigation, consider star shooting order before determining a best assumed position. Shooting the smallest combined adjust first (on eastbound headings) also means obtaining course line LOPs first. Let's see the ideal assumed positions from this technique.

From Figure 4 the loci of ideal assumed positions are spread out. To keep ZN errors small use an assumed position near the course line LOP. This means plotting an 80 to 90 nm speed line intercept. Such plotting distances are needlessly large.

Because of the way motion of the observer is computed, I strongly suggest one rule—***shoot speed lines first, course lines last.***

OCUS OF IDEAL ASSUMED POSITIONS



In this method(Figure5)the loci of ideal assumed positions are clustered about a point on track 4 minutes of GS prior to fix time DR. From a position only 20 to 30 nm from the intended fix point you can expect uniformly good ZNs and small intercepts. For night celestial navigation shooting 12, 8, and 4 minutes early, ***the ideal night celestial assumed position lies on track 4 minutes of GS prior to fix time DR.*** Though shooting speed lines first greatly improves ZN and motion of the observer accuracy, it does involve a tradeoff. Any errors in groundspeed are virtually multiplied by 12 minutes of time. Therefore, GS must be monitored closely. Fortunately the tradeoff is worthwhile. It would take at least 100 knots GS error to duplicate the otherwise error-free boondoggle illustrated earlier.

COURSE LINES FIRST = BAD

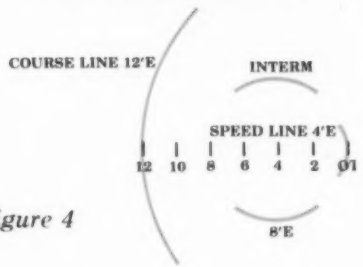


Figure 4

SPEED LINES FIRST = GOOD

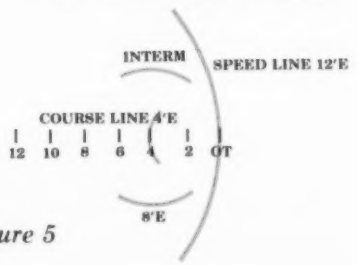


Figure 5

It is sometimes difficult to determine which stars represent what kind of LOP. A simple technique I use is to draw the ZNs on a Star Selection By Azimuth Graph. By including aircraft track (Figure 6) notice that ***nose/tail ZNs are speed lines and wing shot ZNs are course lines.*** Occasionally, two ZNs are equally viable candidates for a particular type of LOP.

When the choice between two stars is a toss-up, shoot the one with the most rapidly changing ZN nearer fix time. Keep in mind that ZN changes rapidly with high Hc and ZN pointing to the equator—ZN changes slowly with low Hc or ZN pointing to the polar regions.

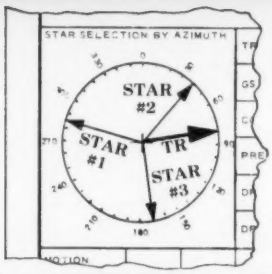


Figure 6

STAR SELECTION BY AZIMUTH GRAPH

As an example, in Figure 6 star #1 and star #2 are both good speed line candidates. If star #1 has a high Hc (e.g. 60°) its ZN will be changing rapidly. In that case shoot star #2 first (speed line). On the other hand if star #1 has a low Hc (e.g. 20°) don't bother changing the shooting order.

Lastly, if the ideal assumed position falls midway between two latitudes, you may want to favor one latitude over another based on the intermediate LOP. Without making any complicated diagrams simply remember: *the ideal position lies toward the star you are flying towards and away from the star you are flying away from.*

As an example, if star #1 in Figure 6 was the intermediate LOP, away from star #1 is right of track; favor the lower latitude. If star #2 was the intermediate LOP, towards star #2 is left of track; favor the higher latitude. For tracks running north/south, the same reasoning applies to assumed longitudes.

Selection of an assumed position and proper shooting sequence can significantly reduce errors and should not be dismissed lightly. If you are interested in competitive navigation, you can further reduce errors by shooting individual LHAs and spinning motion of the observer in flight against current GS. The table in Figure 7 below was especially designed with this in mind and includes a summary of the important principles outlined in this article. Give the principles a try. They are easy to apply and the results will reward your extra effort.

Captain Campbell graduated from Willamette University in 1970. He entered the Air Force through OTS, and then completed UNT and EWT. Following a one-year tour as an AC-130 gunship Black Crow operator, he was assigned to the 524th Bomb Squadron, Wurtsmith AFB, where he is presently a B-52H IEW. His career goal is research and development work through an advanced degree in Physics from AFIT.

NIGHT CELESTIAL MOTION OF THE OBSERVER

1. The ideal assumed position lies on track 4 min GS prior to fix time DR.
2. Shooting order is speed lines first — course lines last.
3. In the event of a toss-up shoot the rapidly changing ZN nearer fix time.
   RAPID = High Hc, ZN towards equator
   SLOW = Low Hc, ZN towards poles
4. If the ideal assumed position falls between two possible assumed positions, favor the one nearest the intermediate LOPs ideal assumed position. It lies TOWARDS THE STAR YOU ARE FLYING TOWARDS AND AWAY FROM STAR YOU ARE FLYING AWAY FROM.
5. With assumed position and shooting order established, use individual LHA to compute Hc and ZN.
6. Enter the table with shot time and TR−ZN or ZN−TR. Extract results, noting whether positive or negative.
7. Set black arrow on computer to GS and above result is motion of the observer.

$$\frac{\text{MOTION OF THE OBSERVER}}{\text{RESULT}} = \frac{\text{GS}}{60}$$

NOTE: Speed lines may be inaccurate unless current inflight GS is used. If shooting order is correct, the result necessarily comes from the boxed-in figures.

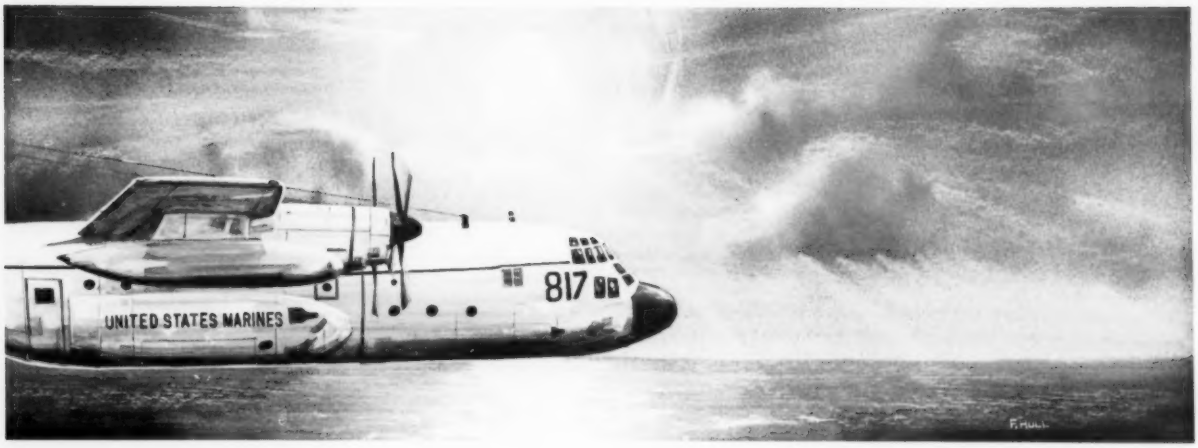
EXAMPLE: TRACK = 167, ZN = 213, GS = 488

1. ZN−TR = 046
2. Star is intermediate line LOP, shoot it 8 min early.
3. For 046, 8 min early: Results = −55.6
4. $\frac{\text{Motion of the Observer}}{-55.6} = \frac{488}{60}$

   Motion of the Observer = −45.2

RESULT NEGATIVE (−)			12 MIN EARLY	8 MIN EARLY	4 MIN EARLY		RESULT POSITIVE (+)	
000	360		120.0	80.0	40.0		180	180
002	358		119.9	80.0	40.0		178	182
004	356		119.7	79.8	39.9		176	184
006	354		119.3	79.6	39.8		174	186
008	352	SPEED LINE	118.8	79.2	39.6	SPEED LINE	172	188
010	350		118.2	78.8	39.4		170	190
012	348		117.4	78.3	39.1		168	192
014	346		116.4	77.6	38.8		166	194
016	344		115.4	76.9	38.5		164	196
018	342		114.1	70.6	38.0		162	198
020	340		112.8	75.2	37.6		160	200
022	338		111.3	74.2	37.1		158	202
024	336		109.6	73.1	36.5		156	204
026	334		107.9	71.9	36.0		154	206
028	332		106.0	70.6	35.3		152	208
030	330		103.9	69.3	34.6		150	210
032	328		101.8	67.8	33.9		148	212
034	326		99.5	66.3	33.2		146	214
036	324		97.1	64.7	32.4		144	216
038	322	INTERMEDIATE LINE	94.6	63.0	31.5	INTERMEDIATE LINE	142	218
040	320		91.9	61.3	30.6		140	220
042	318		89.2	59.5	29.7		138	222
044	316		86.3	57.5	28.8		136	224
046	314		83.4	55.6	27.8		134	226
048	312		80.3	53.5	26.8		132	228
050	310		77.1	51.4	25.7		130	230
052	308		73.9	49.3	24.6		128	232
054	306		70.5	47.0	23.5		126	234
056	304		67.1	44.7	22.4		124	236
058	302		63.6	42.4	21.2		122	238
060	300		60.0	40.0	20.0		120	240
062	298		56.3	37.6	18.8		118	242
064	296		52.6	35.1	17.5		116	244
066	294		48.8	32.5	16.3		114	246
068	292	COURSE LINE	45.0	30.0	15.0	COURSE LINE	112	248
070	290		41.0	27.4	13.7		110	250
072	288		37.1	24.7	12.4		108	252
074	286		33.1	22.1	11.0		106	254
076	284		29.0	19.4	9.7		104	256
078	282		24.9	16.6	8.3		102	258
080	280		20.8	13.9	6.9		100	260
082	278		16.7	11.1	5.6		098	262
084	276		12.5	8.4	4.2		096	264
086	274		8.4	5.6	2.8		094	266
088	272		4.2	2.8	1.4		092	268
090	270		0.0	0.0	0.0		090	270

Figure 7



LAN-HO

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It can be very lonely for a navigator flying over the ocean in the middle of the day with only sun LOPs and DRs to position the aircraft. Perhaps that fix-to-fix wind that you used to estimate the aircraft's position looked pretty shaky, or that Doppler memory light has remained illuminated since you took off. Nevertheless, some of our more sophisticated aircraft have limped through the Air Defense Identification Zone (ADIZ) with minimum navigational aids.

Why do most navigators prefer to fly over the ocean at night rather than during the daytime? Perhaps because there are more celestial aids available to position the aircraft. In most cases, however, the mission must be accomplished during daylight as well as at night.

Until recently, I had resigned my fate to sun and DR MPPs as the only means of locating the aircraft's position in areas void of navigational aids. However, under the supervision of several Marine navigation instructors, Air Force Manual 51-40, and H.O. Publication Number 216, this Air Force navigation instructor has now become the student. By knowing a few basic concepts about day celestial navigation, it is possible to compute, plot, and resolve a sun fix. The accurate term for this procedure is the noon fix. For some of the more experienced Air Force navigators, the noon fix may be something that they vaguely remember from years past. For all Marine navigators, it is a constantly used navigation procedure while most Air Force navigators have very little knowledge of this technique. Therefore, the purpose of this article is to describe the procedure of computing Local Apparent Noon (LAN) and using this information to compute, plot, and resolve a local noon time fix.

As all navigators remember from their day celestial instruction in navigation school, the true bearing of the sun changes rapidly during its transit of the celestial meridian. In general, the higher the sun's altitude in relation to the observer, the more rapid this change will become. If the navigator can calculate the time for LAN, then it is possible to compute one sun line of position prior to LAN, one sun line of position at

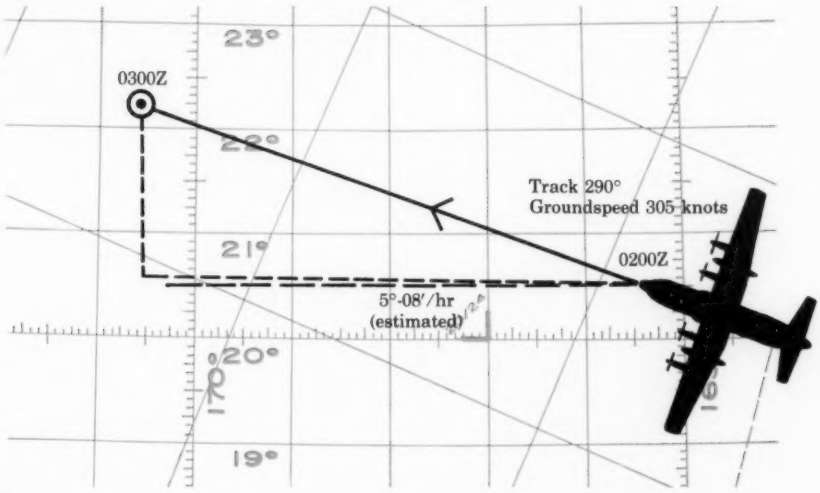


Figure 1

LAN, and one after LAN. Finally, by moving both the early and the late shots to the time of LAN, it is possible to acquire the noon fix.

Local Apparent Noon (School Approach)

Local Apparent Noon is defined as local noon time or the instant the sun is over the upper branch of the observer's meridian, i.e., LHA = 360°. Since the entire procedure is dependent on the rapid true bearing change (Zn) of the sun, it is important to calculate the time along the route of flight at which this noon time will occur. This can be done using the LAN procedure. The following example shows how the information is calculated:

Aircraft: C-130
Position at 0200Z: 20°-30'N, 165°-25'W (Position prior to LAN)
Sun's GHA for 0200Z: 160°-05'
Aircraft's Track: 290°
Aircraft's Groundspeed: 305 knots

First, determine the local hour angle (LHA) for the aircraft's position prior to LAN.

Position Time	0200Z
GHA (Sun)	160°-05'
Longitude (-W +E)	-165°-25'
LHA at 0200Z	354°-40'

Secondly, compute the difference between the sun's LHA 354°-40' and the noon time LHA of 360°-00'.

Noon Time LHA	= 360°-00'
0200Z LHA	= 354°-40'
Difference	5°-20'

Thus, 5°-20' of LHA remains before local noon will occur. This difference will be used later in computing the time of Local Apparent Noon.

Since the aircraft and the sun are moving at different rates, it is important to determine the rate of closure (ROC) between the sun and the aircraft. The rate of closure for the sun is a constant 15 degrees of longitude per hour or 900 minutes of arc (15° X 60'). However, the rate of closure for the aircraft will vary and must be computed by the navigator. This is done easily by estimating the position of the aircraft for one hour in advance (0300Z) and counting the longitudes to be crossed in that hour. (See Figure 1.)

In this example, the aircraft will cross approximately 5°-08' (308 minutes of arc) in one hour. Therefore, the aircraft's rate of closure is 5°-08' or 308 minutes of arc per hour. To compute the total rate of closure for both aircraft and sun, subtract the aircraft's rate of closure (308 minutes of arc) from the sun's rate of closure (900 minutes of arc). However, for ease in doing the calculations, use minutes of arc rather than a combination of degrees and minutes of arc.

Rate of Closure (ROC):

Sun	900'
Aircraft (-W +E)	-308'
Total Rate of Closure	592'

It must be noted that on a westerly heading, subtract the aircraft's ROC from the sun's ROC. On an easterly heading, add the aircraft's ROC to the sun's ROC. Finally, divide the LHA difference computed initially (5°-20'), converted to minutes of arc (320'), by the total rate of closure (592') to determine the time remaining until LAN. The

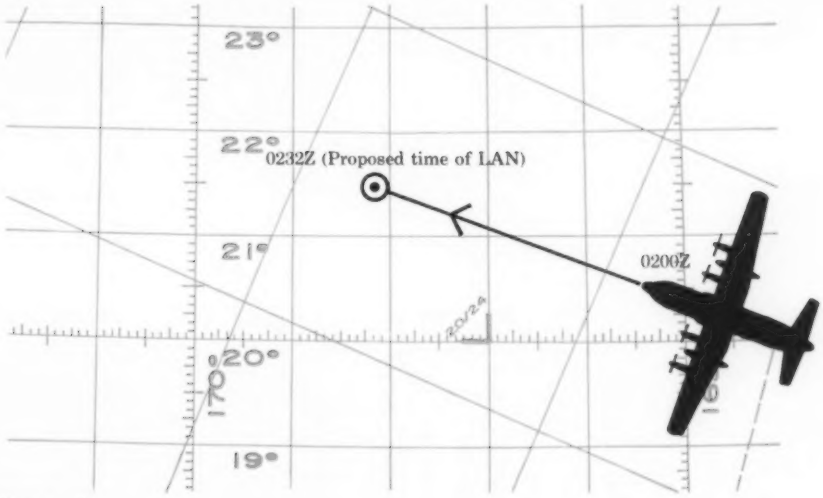


Figure 2

resultant time added to the original position time (0200Z) will become Local Apparent Noon (LAN) along the aircraft's route of flight.

$$\frac{\text{LHA difference (320')}}{\text{Total Rate of Closure (592')}} = \text{32 minutes 26 seconds or approximately 32 minutes remaining until LAN}$$

Thus, LAN is computed by adding the time remaining until LAN (32 minutes) and the position time prior to LAN (0200Z) to obtain LAN (0232Z).

LAN: The Practical Approach

What has just been explained is the technical aspect of determining LAN. However, the practical approach is to establish a constant shooting schedule (20 or 30 minutes). As you prepare your sun precomputations notice the constantly changing LHA. At C-130 speeds, when the LHA reaches 345°, you will have approximately one hour before LAN occurs. If you are heading east, subtract five minutes, or when heading west, add five minutes. This will be the approximate time of LAN. This, of course, is dependent upon the speed of your aircraft and the direction of travel. The amount to be added or subtracted will also depend upon your previous experience working with LAN. The primary idea is to maintain a constant shooting schedule so that the celestial observations are made as close to LAN as possible. This will insure the optimum Zn differences in the LOPs when resolving the resulting fix for the time of LAN.

The Noon Fix

Once local apparent noon has been determined, complete a sun precomputation for the time of LAN (0232Z). It will be necessary to put out a dead reckoning position for that time in order to extract the coordinates for the sun precomputation. (See Figure 2.)

This is important since the assumed latitude for LAN must be known so that the approximate Hc of the sun at LAN can be determined. By knowing the approximate Hc from the H.O. Volume 249, you can determine your shooting schedule. In this particular problem, the assumed latitude is 21° North, the declination for 0232Z is North 7°-05', and the LHA is 360°. Looking in the H.O. 249,

Figure 3

Approximate angles between sun lines of position before and after LAN

Ho at LAN	Minutes before and after LAN											
	04	08	12	16	20	24	28	32	36	40	44	48
°	°	°	°	°	°	°	°	°	°	°	°	°
30											19	21
40								18	20	22	25	27
50						17	20	23	26	29	31	34
60					20	23	27	31	35	38	42	45
65				19	23	28	32	37	41	45	49	58
70			17	23	29	34	39	45	50	55	59	64
75		15	23	30	37	44	51	57	63	69	74	79
80	11	22	33	43	53	62	70	78	85	89	83	78
81	13	25	36	48	58	67	76	83	90	83	77	72
82	14	28	41	53	63	73	82	90	83	77	71	66
83	16	31	44	59	70	81	90	82	75	69	64	59
84	18	36	52	66	79	89	82	74	67	61	56	51
85	22	42	60	76	89	80	71	64	58	52	48	43
86	27	51	72	88	79	68	60	53	47	42	38	35
87	35	65	88	75	63	54	46	41	36	32	29	
88	52	87	69	54	44	37	31	27				
89	87	55	36	28								

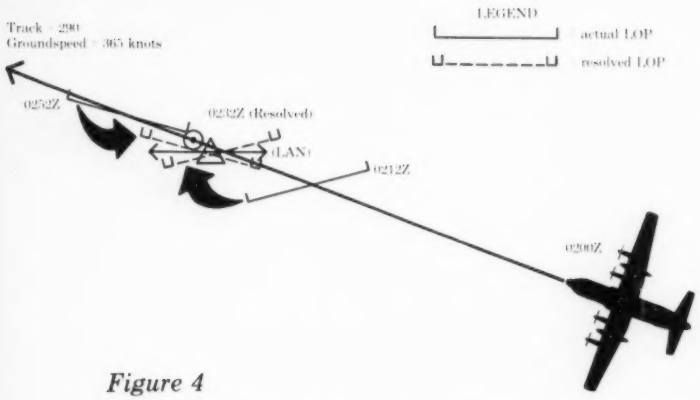


Figure 4

Volume I, the Hc is 76°-00′. Using the following table extracted from the H.O. 216 (see Figure 3), one can determine the shot time. The information needed to use this table is the Ho of the sun and desired angle between the sun LOPs before and after LAN. However, you can use the Hc in place of the Ho to assist you in determining the desired shot times.

In this particular case, we will use a celestial shooting schedule of twenty minutes. According to the table, we can expect an approximate angle of 37° between the sun lines of position. This schedule is arbitrary. However, the farther away from LAN the shot times are, the greater the angles between the sun lines of position will be. (See Figure 3.) Once the shot schedule has been determined, the sun precomputations are completed for twenty minutes before LAN (0212Z), LAN (0232Z), and twenty minutes after LAN (0252Z). After the lines of position are plotted, they are then resolved to LAN (0232Z) (see Figure 4) by using the average track and groundspeed to advance the 0212Z LOP and retard the 0252Z LOP (see Figure 4). Note that both resolved LOPs are plotted parallel to the original LOP.

Basically, the preceding is a method to assist in your daylight navigation when your only celestial aid is the sun. Granted, this procedure is only a once-a-day occurrence and the best results are obtained at the lower latitudes. However, it is a method that may be of some value for you as you "MPP" your way from Travis Air Force Base to Hawaii or from Cherry Point Marine Corps Air Station to the Azores. Nevertheless, the concept of the Noon Fix is a basic understanding of the movement of the sun at local noon time. The only complicated procedure may be computing local apparent noon along your route of flight. Included with this article is a checklist-size handout on computing LAN inflight and a step-by-step guide for obtaining a noon time fix. Overall, the real value of the noon fix is to correct any errors in previous positions and to reestablish the aircraft on track. Even with all the sophisticated computerized equipment on some of our aircraft, a few navigators may find themselves staring at a multitude of off-flags and fail-lights, armed only with their dead reckoning equipment and a sextant. At this point, one must use limited means

LAN COMPUTATION WORKSHEET

Position Time (prior to LAN) _____ :

GHA of Sun	( )
Longitude (-W +E)	( )
LHA of Sun	( )
Transit LHA	(360°00′)
*LHA Difference	( )

Rate of Closure

Sun	(900′)/hr
Observer (-W +E)	( )/hr
**Rate of Closure	( )/hr

Computer Solution:

$$\frac{\text{*LHA Difference}\ (\quad)}{\text{**Rate of Closure}\ (\quad)} = \frac{\text{Time to LAN}}{60}$$

Position Time ( ) + Time to LAN

( ) = LAN ( )

NOON FIX CHECKLIST

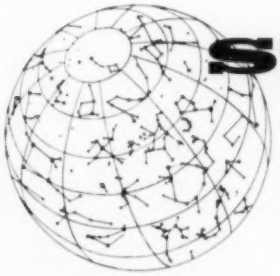
1. Estimate position for LAN.
2. Compute precomputation for LAN.
3. Compare HC with Table 2207 for desired shot schedule.
4. Complete precomputations for shot times.
5. Make Sun observations.
6. Plot lines of position (LOPs).
7. Resolve LOPs to LAN time, using best known groundspeed, time, and track.

NOTE: For ease in calculating LAN, convert degrees and minutes of arc to minutes of arc.

to position the aircraft. Perhaps using the noon fix procedures may provide an easy and effective means to navigate the aircraft safely to its destination.

Captain Pyne is a 1967 AFROTC graduate of the University of Maryland. He has flown as a navigator on the KC-135A and as an instructor on the C-130E. He taught navigation procedures in the 451 FTS prior to assignment as a program developer for the USMC Navigation Program. Captain Pyne presently is assigned to UNT Curriculum Development at Mather AFB.

A graduate of the University of West Florida, MSgt Blake holds a teacher's certificate for Florida and California. He has been a navigator since 1956, and has flown on the C-117, C-119, C-54, and KC-130F. During two tours in Vietnam, he earned 13 air medals. MSgt Blake is presently the senior instructor at the Marine Aerial Navigation School, Mather AFB.



STAR IDENTIFICATION

With the presentation of the remaining 13 stars of the 41 used in HO 249, Volume 1, the article on star identification is concluded.

Each chart presented shows the first, second, third, and fourth magnitude stars that are visible using a sextant with a 15° field of view when the desired star is in the center. On a clear night many more will be visible; on a hazy or moonlit night only the brightest star will show. Lines were included to make the patterns more meaningful. Most of these follow the lines of the better known constellations.

The stars are shown as they would appear from the North Pole. For other latitudes, the accompanying tables of position angles tell how much the charts should be rotated to give the correct presentation for the time of the observation. Dashes indicate that the star is below the horizon at those points.

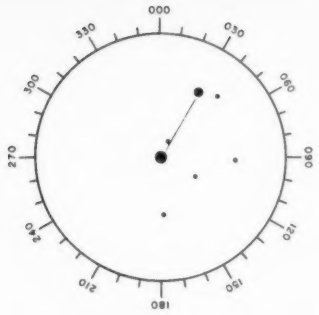
Enter the table with nearest latitude and LHA of Aries to find the position angle. Then rotate the chart until this position angle is at the top. The star pattern will resemble the one sighted in the sextant.

I hope you will find these charts and tables very useful, and will be able to predict exactly what you will see when looking for a particular star.
The Editor

PEACOCK

LHA / LAT	0	30	60	90	120	150	180	210	240	270	300	330
80N	-	-	-	-	-	-	-	-	-	-	-	-
70N	-	-	-	-	-	-	-	-	-	-	-	-
60N	-	-	-	-	-	-	-	-	-	-	-	-
50N	-	-	-	-	-	-	-	-	-	-	-	-
40N	-	-	-	-	-	-	-	-	-	-	-	-
30N	-	-	-	-	-	-	-	-	-	-	005	339
20N	311	-	-	-	-	-	-	-	-	034	006	337
10N	306	-	-	-	-	-	-	-	065	038	006	334
0	301	275	-	-	-	-	-	-	070	041	008	332
10S	295	269	-	-	-	-	-	100	075	046	008	328
20S	290	264	239	-	-	-	-	107	082	052	010	324
30S	281	257	234	211	-	-	135	113	089	060	012	317
40S	271	249	229	207	185	161	140	119	098	071	016	305
50S	258	240	222	204	184	164	144	128	109	090	033	282
60S	240	229	215	200	184	167	151	136	125	116	144	243
70S	217	214	206	195	182	170	158	149	142	140	174	207
80S	197	198	194	189	181	174	168	163	163	167	178	190

POLLUX



LHAT / LAT	0	30	60	90	120	150	180	210	240	270	300	330
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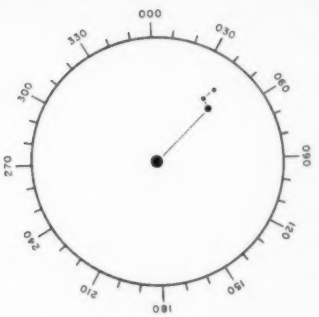
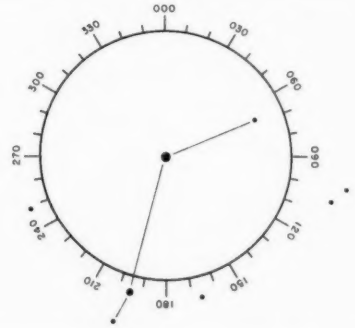
70N	019	023	021	012	358	345	338	338	343	351	001	012
60N	028	034	033	022	356	333	326	328	336	347	-	016
50N	035	044	046	035	353	320	313	318	327	-	-	-
40N	043	054	060	054	346	302	300	308	-	-	-	-
30N	-	065	074	079	301	282	289	298	-	-	-	-
20N	-	074	086	103	206	263	277	290	-	-	-	-
10N	-	083	097	122	193	248	267	280	-	-	-	-
0	-	092	107	134	188	235	257	-	-	-	-	-
10S	-	-	117	143	186	226	248	-	-	-	-	-
20S	-	-	125	149	185	218	240	-	-	-	-	-
30S	-	-	133	155	184	212	231	-	-	-	-	-
40S	-	-	141	160	184	207	223	-	-	-	-	-
50S	-	-	-	163	183	201	-	-	-	-	-	-
60S	-	-	-	-	182	-	-	-	-	-	-	-
70S	-	-	-	-	-	-	-	-	-	-	-	-
80S	-	-	-	-	-	-	-	-	-	-	-	-

PROCYON



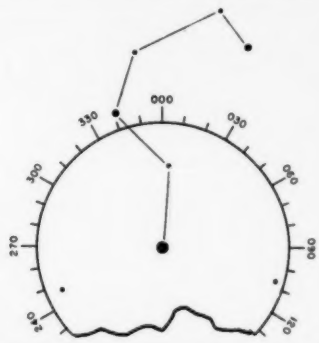
LHAT / LAT	0	30	60	90	120	150	180	210	240	270	300	330
80N	009	010	008	004	359	354	351	350	352	-	-	-
70N	-	020	017	009	358	347	341	340	-	-	-	-
60N	-	030	026	014	356	340	332	330	-	-	-	-
50N	-	040	036	021	355	332	321	320	-	-	-	-
40N	-	051	046	029	352	322	311	310	-	-	-	-
30N	-	060	058	040	348	310	301	-	-	-	-	-
20N	-	070	069	057	338	295	289	-	-	-	-	-
10N	-	081	082	079	304	279	278	-	-	-	-	-
0	-	090	094	103	225	262	267	-	-	-	-	-
10S	-	101	106	123	201	246	257	-	-	-	-	-
20S	-	110	118	139	193	233	246	-	-	-	-	-
30S	-	120	128	149	188	222	236	-	-	-	-	-
40S	-	130	138	157	186	212	226	-	-	-	-	-
50S	-	-	147	162	185	205	217	-	-	-	-	-
60S	-	-	155	168	183	198	208	-	-	-	-	-
70S	-	-	164	172	182	192	198	-	-	-	-	-
80S	-	-	172	176	182	186	-	-	-	-	-	-

RASALHAGUE



LHAT / LAT	0	30	60	90	120	150	180	210	240	270	300	330
80N	350	352	356	001	006	009	010	008	005	359	354	350
70N	340	344	-	-	-	018	020	017	009	357	347	341
60N	330	-	-	-	-	-	031	027	015	356	339	331
50N	320	-	-	-	-	-	041	037	022	354	329	319
40N	311	-	-	-	-	-	051	049	033	350	318	309
30N	301	-	-	-	-	-	061	062	048	344	304	297
20N	-	-	-	-	-	-	071	074	068	325	288	286
10N	-	-	-	-	-	-	081	086	093	252	271	275
0	-	-	-	-	-	-	092	099	115	207	254	265
10S	-	-	-	-	-	-	101	110	132	195	240	255
20S	-	-	-	-	-	-	111	120	143	191	229	244
30S	-	-	-	-	-	-	-	130	152	187	219	235
40S	-	-	-	-	-	-	-	140	158	186	211	225
50S	-	-	-	-	-	-	-	148	164	184	204	216
60S	-	-	-	-	-	-	-	156	168	183	198	207
70S	-	-	-	-	-	-	-	164	172	182	191	-
80S	-	-	-	-	-	-	-	-	-	-	-	-

REGULUS



LHAT / LAT	0	30	60	90	120	150	180	210	240	270	300	330
80N	005	009	010	009	006	000	355	351	350	351	355	000
70N	-	027	020	019	012	001	350	342	340	342	-	-
60N	-	-	030	029	020	001	343	332	330	-	-	-
50N	-	-	041	040	028	002	335	321	319	-	-	-
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30N	-	-	060	062	054	006	309	298	299	-	-	-
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0	-	-	-	096	108	171	249	262	270	-	-	-
10S	-	-	-	107	124	175	233	252	260	-	-	-
20S	-	-	-	117	135	176	221	242	-	-	-	-
30S	-	-	-	127	145	177	212	232	-	-	-	-
40S	-	-	-	136	152	178	205	223	-	-	-	-
50S	-	-	-	145	158	178	200	213	-	-	-	-
60S	-	-	-	154	164	179	194	-	-	-	-	-
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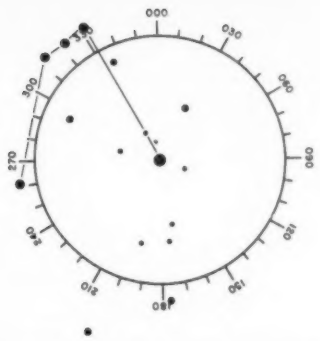
RIGEL



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10S	098	096	097	259	264	263	-	-	-	-	-	-
20S	109	110	126	223	249	252	-	-	-	-	-	-
30S	119	122	145	206	235	240	-	-	-	-	-	-
40S	129	135	156	196	223	230	-	-	-	-	-	-
50S	140	146	164	191	212	220	-	-	-	-	-	-
60S	150	155	169	187	203	210	209	-	-	-	-	-
70S	160	164	174	185	194	200	200	-	-	-	-	161
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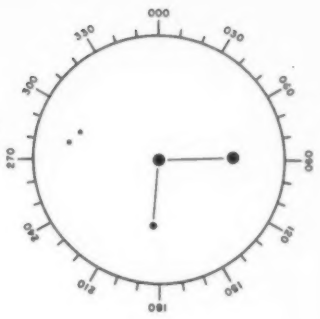
RIGIL KENTAURUS



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40N	-	-	-	-	-	-	-	-	-	-	-	-
30N	-	-	-	-	-	-	-	-	-	-	-	-
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0	-	-	-	-	-	072	044	012	337	306	279	-
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60S	203	186	168	152	136	121	107	094	261	248	234	219
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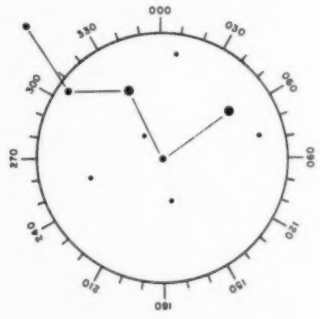
SCHEDAR



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30N	160	217	255	280	303	327	-	-	042	064	088	116
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20S	171	198	224	-	-	-	-	-	-	-	-	144
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40S	-	-	-	-	-	-	-	-	-	-	-	-
50S	-	-	-	-	-	-	-	-	-	-	-	-
60S	-	-	-	-	-	-	-	-	-	-	-	-
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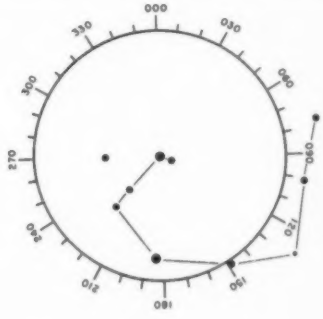
SHAULA



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50N	-	-	-	-	-	-	-	-	014	355	-	-
40N	-	-	-	-	-	-	-	-	017	354	331	-
30N	-	-	-	-	-	-	-	043	020	353	326	-
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50S	224	211	194	-	157	142	130	126	135	203	233	233
60S	215	204	191	176	162	150	142	142	154	191	215	220
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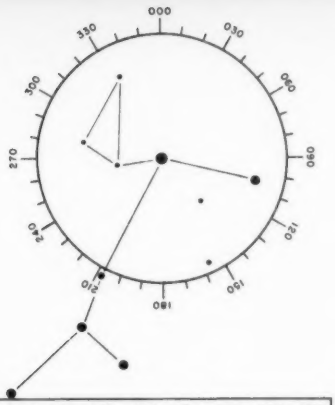
SIRIUS



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50N	-	037	026	007	347	330	-	-	-	-	-	-
40N	-	047	032	009	342	322	-	-	-	-	-	-
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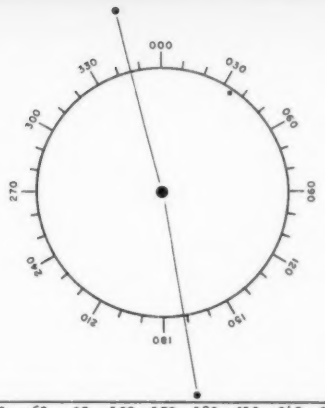
10S	-	095	087	059	285	271	263	-	-	-	-	-
20S	-	105	102	115	255	258	252	-	-	-	-	-
30S	121	116	118	149	229	244	243	-	-	-	-	-
40S	131	128	133	162	212	230	232	-	-	-	-	-
50S	140	138	146	169	201	218	221	217	-	-	-	-
60S	150	149	157	173	193	207	211	209	-	-	-	-
70S	160	160	166	176	188	197	201	199	192	-	-	165
80S	170	171	173	178	184	188	191	190	187	182	177	172

SPICA



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60S	-	-	-	152	149	154	167	187	203	210	210	-
70S	-	-	-	162	159	163	173	184	195	199	200	-
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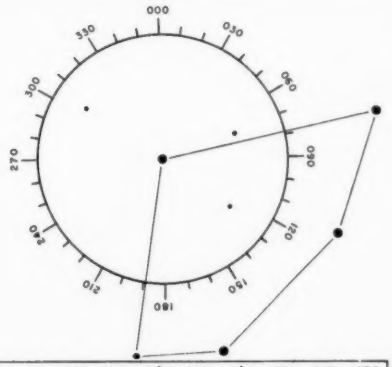
SUHAIL



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60N	-	-	-	-	-	-	-	-	-	-	-	-
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30S	-	122	104	084	048	317	277	256	239	-	-	-
40S	148	130	115	100	077	286	262	247	231	213	-	-
50S	153	137	126	117	125	233	243	235	224	208	189	171
60S	158	147	138	137	154	203	223	222	214	203	188	173
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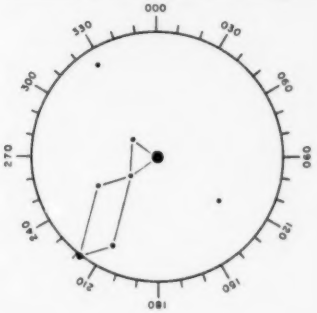
VEGA



LHA / LAT	0	30	60	90	120	150	180	210	240	270	300	330
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70N	334	339	347	357	008	017	024	025	020	005	346	336
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40N	300	314	-	-	-	037	053	065	074	069	284	290
30N	290	307	-	-	-	-	061	076	093	138	253	275
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70S	-	-	-	-	-	-	-	-	-	-	-	-
80S	-	-	-	-	-	-	-	-	-	-	-	-

With the . . . RAF

Major Charles G. Wade
No. 12 (Bomber) Squadron
RAF Honington

QUESTION: Why was a USAF navigator with a USN pilot in a Buccaneer on the bow catapult of a British carrier? ANSWER: For the same reason a USAF pilot was with a Royal Navy observer flying a RAF Buccaneer from a Danish airfield. EXPLANATION: One pilot and one navigator—alias Smith and Wade—share the unique privilege of being the only USAF crew flying the Hawker Siddeley Buccaneer.

As members of Number 237 Operational Conversion Unit (OCU), RAF Honington, Captain Ben Smith and I not only fly training sorties but also have frequent opportunities to join operational squadrons and gain additional experience. Front line Buccaneer squadrons serve in a wide variety of roles including carrier based strike/attack, land based strike/attack against land targets, and land based maritime operations. The aircraft can be configured for photo reconnaissance, air-to-air refueling in the receiver and tanker roles, nuclear strike, conventional attack, and maritime attack using the Martel stand-off missile.

A quick guided tour around the aircraft generally changes the first impression of an ungainly beast with two pointed ends. The application of area rule generated the large bulge just aft of the jet pipes. This space provides a veritable cavern in which black boxes are swallowed with room to spare. The stinger-like protuberance at the tail is merely an enormous barn door airbrake that is of great use tactically as well as providing a means of operating at low speed with a high power setting. High RPM is needed to supply Boundary Layer Control bleed air to the entire leading and trailing edges of both the main plane and the tail plane. This high lift compensation, coupled with a system of flaps and "drooped" ailerons extending the full length of the main plane, provides satisfactory low speed handling characteristics without modifying the basic wing shape which is optimized for high subsonic flight at sea level. An internal weapons bay and large capacity internal fuel tanks keep the design aerodynamically clean. Underwing "slipper" tanks have the same "G" and mach limits as the basic airframe and their airfoil shape creates lift. The Rolls Royce Spey bypass engines produce enough thrust to exceed airframe limits, yet the 420 knot cruise (sea level) fuel consumption is only 110 pounds per minute. The Buccaneer's unbelievably sturdy airframe (rumor: wing spars are quarried in the Alps) provides a capability to stay low in turbulence unacceptable to other designs.

Buccaneer S Mk 2D "Hooking on" HMS Ark Royal

What is low level? You can fly an airplane right down to five feet, but that's for the Red Arrows [*British aerial demonstration team*]. It's an altogether different story talking about how low an aircraft can fight. Straight and level flight at 30 feet and maneuvering flight (up to 90° angle of bank) at 100 feet are the practical limits. Buccaneer routine operational training sorties are not authorized below 200 feet AGL or 100 feet ASL and Strike Progression (an exercise in progressing a formation of four Buccaneers along a designated Mean Line of Advance while warding off menacing aircraft) is not allowed below 500 feet. These realistic training limits are a great advantage as they enable crews to practice close to the parameters they will be expected to achieve in combat. Extensive training is the key before a crew is ready to attack with and defend a single Buccaneer, much less a six ship battle formation.

The OCU trains crews in all Buccaneer operating modes. Investigating the cockpits reveals the systems used. The forward cockpit is roomy and has a conventional layout with an integrated flight instrument system and the typical selection of dials and switches. On the weaponry side, a heads-up strike sight, attack selector, and release switches are provided. The rest of the nav-attack system is in the rear office.

The aft cockpit is, by contrast, small and crowded; nevertheless, the navigator's forward visibility is very good. The large bubble hood (canopy) permits an unimpaired view from the seven o'clock to eleven o'clock and the twelve o'clock to five o'clock positions. Forward visibility is enhanced by the ejection seats being displaced two inches off center in opposite directions. This also facilitates easy rear cockpit monitoring of critical flight systems displays in the front cockpit. Basic navigation equipment includes a small folding chart board, computer and plotter stowage, rally-master and stop watches, plus standard flight instruments. To back up the basics, a nav-attack radar, two ground position indicators, and track, ground speed, and wind displays are available. General equipment consists of UHF and HF radios, IFF, a control panel for the three auxiliary fuel systems, and all the other usual paraphernalia. The bulk of space is occupied by weapons equipment.

Up to three passive ECM systems can be fitted along with a multi-program active pod giving coverage over the required spectrum of land, sea, and air radars. Iron bomb and rocket switches are a permanent fit while other weapons are controlled through a selection of removable panels. These "role panels" are installed as needed to provide the navigator proper control and include bomb bay mounted reconnaissance cameras, under wing refueling pod (for refueling other aircraft), radiation and TV guided Martel missiles, or special weapons. All of this equipment surrounds the navigator. The last bit of space (one cubic foot between the navigator's legs) is occupied by a Martel TV screen. Like most modern warplanes, the Buccaneer is a complicated piece of equipment. Despite the complexities of the system, the majority of effort on the conversion course is consumed in teaching basic combat flying.

The RAF places great emphasis (and rightly so) on the fundamental aviation skills which are commonly categorized as airmanship. Sophisticated equipment is an aid designed to enable the aviator to cope with more functions in less time and to extend human capabilities. Flying a complex automated system increases (rather than diminishes) the need for sound airmanship. ***WITHOUT*** airmanship, the well trained navigator is an extension of the "system" and the result is effective operation of equipment within its design limits—the weapon system operator is an expedient bridging the technological gap between semi-automatic and

Buccaneer S Mk 2B with Martel Missiles

Buccaneer S Mk 2D refueling

full automation. ***WITH*** airmanship, the system becomes an extension of the navigator and the result, in operational effectiveness, is a technological improvement on his ingenuity and savvy—the essence of the manned weapon system concept.

Airmanship is more easily advocated than taught. The difficulty arises from the intangibility of those attributes which comprise airmanship. I believe airmanship is the degree to which an aviator is aware of his surrounding and can anticipate its consequences. As this ability exists only in the mind of the individual, it cannot be observed until he is placed in a situation requiring a demonstration of his awareness. In the Buccaneer world, the most demanding situation is maneuvering formations in the low level environment. To keep this demanding situation from becoming dangerous, students progress slowly and deliberately within the framework of a six-month course.

Pilot and navigator students fly roughly the same progression through the course. Recently, I read about some USAF officers expressing surprise at pilots teaching student navigators at Mather. Here it is a way of life. Captain Smith spends sixty percent of his airborne time teaching and evaluating navigators. He takes the student up on his first two familiarization sorties and then certifies him safe to fly with his own pilot. Student pilots get one sortie with an instructor pilot even though there are no dual control Buccaneers. After that, I step in and play Ben's role in reverse—instructing and evaluating pilots. When both students are trained, they are off on their own to complete aircraft familiarization.

After the familiarization phase comes high level navigation with two instructor rides for the student nav and two student-crew sorties. Low level navigation is next—two sorties with an instructor pilot or navigator and two student-crew sorties. By now, we know who will hack formation without creating a "nasty." The requirement for accurate navigation, skillful handling, superior lookout, and sound airmanship is redoubled as the routine of instructor/student sorties followed by student-crew sorties is repeated. Strike Progression is the last phase in the first third of the course.

The first sortie of the phase is flown in a thoroughly rehearsed set-piece situation at high level (around 10,000 feet) with an instructor in the front or back seat. Steady progress is then made toward the low level environment while the attacker—either a Buccaneer or a Hunter flown by instructors—becomes more aggressive. This is a superb means of honing a fine edge on handling, lookout, and airmanship. An early sighting followed by clear, concise commentary and correct action is essential. The rule is, "He who sees controls the formation." As the navigator's lookout sector is the vulnerable six o'clock, he is often first on the radio. After that, it's "turn and maneuver" until the "bounce" (attacker) calls out. From this phase the course progresses to academic weaponry and, finally, to hi-lo-hi profiles flying complex events. All of this usually leads to graduation and duty anywhere from the South Atlantic aboard Ark Royal [*British ship*] to the banks of the Maas with RAF Germany.

While graduates scatter to the wind, Captain Smith and I keep on instructing. It's great being able to teach others and at the same time learn so much. What could be better than getting a career broadening assignment while staying in the cockpit? There was a time when I thought assignments like this were made in some mysterious manner and were reserved for the chosen few. Nothing could be further from the truth. All it takes is hard work and a sensible plan laid out in cooperation with the appropriate AFMPC Career Management Section.

Commissioned through OTS in 1963, Major Wade completed navigator training and was assigned to ADC. In 1975, he served in Vietnam, followed by service on a wing staff, TDY to SOS, F-4 training, and a return to Vietnam. Next, he served at the Air Force Academy where he became Director of the Advanced Navigation Course. Major Wade presently is assigned to exchange duty with the Royal Air Force.

Photos by A1C Eleanor Guerrero

The Navig

Major Edward P. Spellacy
323 FTW/DOVN
Mather AFB, CA

"Hey, Nav! Where's the Navigator Memorial Park?" Rather than respond with a blank stare or a "Stand by one", read on to learn all about the newest addition to navigator memorabilia—Mather AFB's Navigator Memorial Park. You'll discover where and what the park is, how it got there, and why it is a fertile growth area in which all navigators can share.

The park is on the western half of a rectangular field about one quarter mile from the departure end of Runway 22L at Mather AFB. For further orientation, the field is just one block south of the Navigator-Bombardier Training building. Present park dimensions are 200 feet wide by 300 feet long, with a potential for further growth into the eastern half of the field.

A visitor probably will be drawn first to the enshrined T-29 "Flying Classroom" positioned at the west end of the field. This aircraft, serial number 33489, was one of the last T-29s to fly a navigation training mission at Mather AFB. The last flight, on 5 March 1975, marked the end of an era as the T-29 closed out 25 years of navigator training to make way for the all-jet lineup of T-37s and T-43s. Six months after the last mission, faithful old "489" was towed to her present home to proudly represent all her fine Convair friends who were instrumental in training over 50,000 navigators. The aircraft, chocked in concrete, is surrounded by a bed of small rocks and a perimeter sidewalk. Visitors are encouraged to take photographs, but there are no provisions for actually boarding the craft. A handsome plaque near the airplane briefly outlines the proud history of the "Flying Classroom."

Looking east from the aircraft down a six-foot wide concrete sidewalk, the visitor will see an octagonal structure with a conical roof—the Navigator Memorial. Approaching the Memorial, one will see numerous hand-crafted benches located on either side of the 200 foot walk, as well as numerous shrubs and small trees. The plantings and grass are watered by a large underground sprinkler system.

The Memorial is on a circular concrete pedestal about 15 feet in diameter and raised 6 inches above ground level. The gold-colored building is 15 feet high, with its round roof dressed in cedar shakes. Each of the structure's eight sides is bordered by stained walnut trim and decorated with a brightly colored plaque. There is a plaque for the 323d Flying Training Wing at Mather, and one for each of the seven flying training squadrons in the Wing. On the side of the octagon facing the T-29 is an engraved rendition of the stirring poem, "Silver Wings", written by Marvin Petersen, a retired civilian employee of Mather.

The puzzled visitor might then ask, "How did all this come about?" In November 1975, the three Deputy Commanders at Mather were tasked to develop a bicentennial project for each of their deputates to be completed by 4 July 1976. Colonel Leo D. O'Halloran, presently the Wing Vice Commander at Mather, was the Deputy Commander for Operations (DO) at that time and decided that the field on which the T-29 was enshrined could be developed into a full-scale park. Thus began the DO Bicentennial Park Project, under the direction of Lt Col Walter Miller, then Commander of the 454th Flying Training Squadron (T-43 pilots).

ator Memorial Park

The objective was to transform a barren, "browned-out" (non-irrigated) field into a first-class park with abundant vegetation, sidewalks, benches, a navigator memorial structure, and a children's play area. The proposed plan was sent to Air Training Command for approval. Joy was somewhat restrained when the word came back from ATC—the plan, excepting the children's play area, was approved with all work to be done on a self-help basis and no Air Force funds.

The proposed completion on 4 July 1976 became impossible since final project approval was received only two months prior to that day. Pessimists close to the operation suggested changing the name to the Tricentennial Park Project—surely it would be done by 4 July 2076. In fact, the project was completed in February 1977 and, by that time, had become designated the Navigator Memorial Park.

Considerable personal sacrifice and dedication went into construction of the park. The intrepid amateurs begged and borrowed help and supplies when they couldn't perform an operation themselves. Generous contributions of time, labor, and resources were given by such diverse groups as the Civil Engineering Squadron, the Field Maintenance Squadron, the California Army National Guard with helicopter support (the roof of the Navigator Memorial was airlifted from another location on base), navigation students, the Mather Officers Wives' Club, and some local merchants. Two young officers associated with the project accomplished "over and above" and, in a way, symbolize the close cooperation from all agencies involved. Capt Frank Petryszak, a T-43 pilot Flight Examiner in the Standardization Division, gave generously of his design and carpentry skills to mastermind the construction of the Navigator Memorial. Capt Mike Maloney, a staff navigator in the Operations Division, spent much of his free time becoming an expert in building sidewalks and sprinkler systems. His many weekends at the park site are reflected in the professional quality of the sidewalks and sprinklers.

Hopefully, this article has adequately described the what, where, and how of the Navigator Memorial Park. It is important to point out that this park truly belongs to all the navigators of the Air Force, both active and retired. A visit to Mather should certainly include a stop at the Navigator Memorial Park, as well as a short walk to its nearby companion attraction, the Navigator Museum (featured in the Spring 1977 issue of this magazine). There is still adequate space at the park site for tasteful integration of other navigator artifacts and memorabilia. You, the navigator, are encouraged to make suggestions for future improvements to what is already an outstanding achievement. If there are particular items that you would like to see in the Navigator Memorial Park, please pass along your thoughts to the Editor, *THE NAVIGATOR Magazine*. In this way, you can help make a good thing even a little better.

A graduate of Golden Gate University, Major Spellacy completed NBT in 1964. He was assigned to B-52s at Blytheville AFB, Pease AFB, and Loring AFB where he was a Radar Navigator Flight Examiner. In 1973, he was assigned to Mather AFB where he has served as an NBT instructor, curriculum liaison officer, and presently is the Chief, Navigator Stan/Eval Branch. He was the project officer for the Navigator Memorial structure.

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